BUILD UP Skills
– Croatia –

Updated and upgraded National Status Quo Analysis:
Current state of construction in Croatia

CRO skills RELOAD

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0. Executive summary

Number of current professionals in the building sector for Croatia (breakdown for the main professional groups)

In 2022, 33,638 legal entities were registered in the Construction sector in the Republic of Croatia, of which 19,469 were active. In the same year, 10,570 trades were registered. In 2022, 44,107 persons were employed in Building Construction, 43,687 persons were employed in Specialized construction activities (which include all other compatible professions such as mechanical engineering, electrical engineering, finishing and other construction works), in trades and free professions that operate in the field of construction 23,965 persons were employed, and 27,320 persons were employed in architectural activities and engineering. The structure of employees according to the European Qualification Framework (EQF) was 0.15% of employees with EQF8 level, 19.01% employees with EQF7 level, 5.64% employees with EQF6 level, 2.14% of employees with level EQF5, 42.14% of employees with level EQF4, 18.65% of employees with level EQF3, 5.44% of employees with level EQF2 and 6.83% of employees with EQF1 level. In addition, according to the data from Croatian chambers of architects and engineers of construction, electrical engineering and mechanical engineering as of June 30, 2022 a total of 13,759 persons were licensed for designing, performing supervision, managing construction sites and works, or construction auditing. The structure of this type of employees according to the European Qualifications Framework was 3.42% of employees with EQF8 level, 79.91% employees with EQF7 level, 16.00% employees with EQF6 level and 0.67% of employees with EQF5 level.

Current energy consumption in Croatia and in the building sector

In 2021, direct (final) energy consumption in the Republic of Croatia amounted to a total of 291.54 PJ, that is 80,983 GWh, of which energy consumption in buildings amounted to 38,224 GWh, that is 47.2% (of the total consumption of buildings, industry, transport, construction and agriculture). In the same year, the total energy produced from renewable energy sources (RES) in buildings amounted to around 13,680 GWh - 13,058 GWh from firewood and biomass, 194.44 GWh from heat pumps, 74.89 GWh from geothermal technology for heating buildings, 198.50 GWh from solar thermal systems and 153.38 GWh from photovoltaic power plants.

2030 energy targets for Croatia and expected contribution of the building sector

According to the *Integrated National Energy and Climate Plan for the Republic of Croatia by 2030*, the total goal of energy efficiency or cumulative energy savings is 125.3 PJ or 34,722 GWh. According to the same source, energy renovation of buildings based on all planned energy renovation programs and related measures should contribute to this goal by 2030 with 35.52 PJ or 9,867 GWh of realized savings. In addition, the expected energy production from RES in buildings in 2030 will amount to a total of 16,123 GWh.

Number of building professionals to be trained in each sub-sector/profession and to each EQF level in order to achieve the 2030 energy targets

To achieve the 2030 energy targets, a significant number of building professionals will need to be trained in each sub-sector/profession, and at each European Qualifications Framework (EQF) level. Within the document, it has been determined that a minimum of 500 to 1200 VET workers (at levels 4 and 5 according to the

European Qualifications Framework) need to be annually trained in the construction industry to ensure the energy goals until 2030. Furthermore, it is specified that 435 civil engineers, 290 architects, 145 mechanical engineers, and 145 electrical engineers need to be educated each year.

Qualification needs: required qualification courses by EQF level and schemes, number of required trainers, training and accreditation structures for carrying out the trainings.

Croatia has regulations that govern the training of vocational workers in energy efficiency (EE) and renewable energy sources (RES) in the construction industry (at levels 4 and 5). These regulations include the *Ordinance on the Education and Certification System for Construction Workers involved in the installation of building components affecting the energy efficiency of buildings, and the Ordinance on Requirements and Criteria for the Establishment of a Quality System for the Certification of Installers of Renewable Energy Sources - Photovoltaic Systems, Solar Thermal Systems, Small Boilers and Biomass Heating Systems, Shallow Geothermal Systems, and Heat Pumps* [1]–[5]. These regulations prescribe the conditions for issuing approvals to Training Providers, which also include requirements for individuals conducting the training (trainers).

Within the CROSKILLS II program, 120 trainers have been educated, which is considered sufficient for training vocational professionals in the field of energy efficiency. However, all experts (trainers) must undergo training to equip vocational workers with knowledge of energy efficiency and renewable energy sources. The regulations define the conditions that trainers and training centers must meet, and future worker education must comply with these regulations.

Existing trainer training programs and worker training programs need to be adjusted to match the required skills outlined in Chapter 7.3, as well as to align and adapt to additional conditions for financing education through green job vouchers. For example, the education program developed as part of the CROSKILLS II project needs to be revised and aligned with market needs (as defined in Chapter 7.3).

For the purpose of training engineers, 15 trainers from the fields of civil engineering and architecture, as well as 10 trainers from the field of mechanical engineering and 10 from the field of electrical engineering, are needed. Additionally, it is necessary to develop training programs for engineers, including all necessary equipment (models, presentations, literature), and tailor the training to the areas of design, supervision, and implementation. The minimum education for each profession at levels 6 and 7 should last for 10 hours.

Courses and professional development programs should be conducted by institutions authorized by the Ministry of Physical Planning, Construction and State Assets for professional training programs in accordance with the provisions of the *Ordinance on professional training of persons performing physical planning and construction activities* (OG 55/2020) [6].

1. Introduction

The European Union has set ambitious goals for sustainable development, as stated in *the European Green Deal and* the *Sustainable Development Goals*. The 2030 Climate Targets Plan is a key part of these efforts, and the Commission is proposing to increase the European Union's (EU) commitment to reducing greenhouse gas emissions. Specifically, the goal is to reduce emissions to at least 55% below the 1990 level by 2030. This plan is aligned with the EU's general goal of achieving climate neutrality by 2050. Croatia's experience shows that energy-efficient renovation and low-energy building construction represent significant challenges for construction and related industries. In order to achieve the goals of the EU directives on energy efficiency, the construction sector must increase the number of skilled workers, including craftsmen and entrepreneurs with special knowledge and expertise in using new technologies and ensuring high-quality construction. Measures are needed to ensure the preconditions for the valuation of qualified labor on the labor market, including regulations and recommendations. The construction of buildings with low energy consumption requires quality execution of works with attention to the smallest details of the building envelope and installed technical systems.

Current Croatian and European strategic documents and development goals emphasize the need to achieve greater energy efficiency in the building sector in order to reduce greenhouse gas emissions and meet other environmental goals. These documents also recognize the importance of training and developing a skilled workforce capable of implementing new technologies and construction practices.

The Croatian government has taken several steps to promote energy efficiency in the building sector, including the creation of *the National Strategy for Sustainable Development until 2030* [7] and the establishment of the Energy Efficiency Fund. The strategy aims to improve the energy efficiency of buildings by promoting the use of renewable energy sources and implementing measures to reduce energy consumption. The Energy Efficiency Fund provides financing for energy efficient renovation projects, including loans and grants. In conclusion, the construction sector plays a key role in achieving the EU's energy efficiency goals and reducing greenhouse gas emissions. To achieve these goals, it is necessary to develop a qualified workforce capable of implementing new technologies and construction practices.

As the attached analysis will show, in order to achieve the goals of the EU directives with the mentioned energy-efficient (EE) works in the construction fund, it is necessary to increase the number of qualified workers on the market, i.e. to create a workforce (workers, engineers) who have the appropriate knowledge or are specialized in jobs at the performance of which use new technologies and who can guarantee the quality of the performance after the work is done. It is also necessary to develop measures that will ensure the prerequisites for the evaluation of qualified labor on the labor market (regulations, recommendations). Although additional qualifications for workers who build passive or near-zero energy buildings may seem unnecessary, the qualifications have proven to be crucial for the quality of construction work (and even for the construction of buildings in accordance with the plans and rules of the profession). The construction of buildings with low energy consumption requires quality execution of works with careful execution of the smallest details of the building envelope and installed technical systems.

At the beginning of the report (**the second chapter**), an explanation of the purpose of data collection for this analysis is given, with an emphasis on the methodology. Namely, the objectives and methodology of data collection and setting of questionnaires for craftsmen and educational institutions (VET, higher education

and lifelong education) were explained. Furthermore, the data obtained by these questionnaires, as well as their analysis in relation to the total figures and indicators, are explained in detail.

Chapter Three gives the description of the future needs for skilled workforce, putting in the perspective the Croatian national policies and strategies to contribute to the EU 2030 energy and climate targets in buildings. This section paints the picture of national context in terms of strategy in the field of energy and in the field of continuing education and training. By means of analysing the accessible data, there has been an attempt at providing a coherent overview on the present market trends and forecast, as well as at underlining the main factors of changes that already have influenced the sector and could do so in the near future.

Chapter Four, through the analysis of relevant national programmes, provides all the relevant data and indicators for the construction sector with the accompanying explanations, which means the building stock sector in particular, i.e. the types of buildings and the dynamics of their construction and refurbishment. As to the EE and the contribution of the building stock to it, an overview has been given of the number of low energy buildings and the annual rate of constructing and refurbishing of the buildings of the kind.

Chapter Five compiles the information about the current situation regarding the education and training of all professionals in the building value chain, from vocational education, through higher education to finally lifelong education programmes. Continuously, **Chapter Six** gives an overview of the national project relevant to education of construction workforce. Together, these two sections give a comprehensive insight into the training and education of craftsmen, other on-site workers, installers of technical systems, as well as engineers in the construction sector and it in turn includes the national education/training system for the afore mentioned people, the bodies responsible for the education/training and the bodies that issue certificates as well as the institutions that offer education and are relevant for the sector. The existing courses and educational schemes for EE and RES in the realm of construction have as well been analysed.

Chapter Seven gives an overview of the skills gaps between the current situation and the needs for 2030. By means of gathering feedback from the craftsmen and entrepreneurs in the field of construction, the project consortium identified the skills and knowledge which the future workers will need and roughly estimated the number of workers in particular activities/sectors that will be needed. The estimates include some proposals as well as the most convenient ways of training and qualifying, including the necessity of additional trainings, and employing instructors/teachers and identifying qualifying and certifying bodies.

Chapter Eight gives an insight into the preliminary analysis of the obstacles (concerning construction workers) to the attaining of the national and EU 2030 objectives. **Chapter Nine** gives conclusions drawn based on the Status Quo Analysis.

2. Objectives and methodology

2.1. Objectives

The main goal of creating the document is to define and quantify the needs of quality workforce of the Croatian construction sector in terms of contribution to the national goals of EE and RES. The analysis includes the analysis of strategic documents at the level of the Republic of Croatia in the building sector and renewable energy sources, the state of education both in secondary schools (level 4 and 5) and in higher education (level 6 and 7) in the construction sector, the current state of the workforce on the labor market and the content of educational programs and curricula in vocational education, higher education and training, and identifying the existing level of knowledge of construction workers about procedures and technologies of EE construction and use of RES. Opportunities and lifelong learning programs available to workers were also analysed. The main goal to be achieved with this analysis is to define - in accordance with other available strategic documents concerning the construction sector and its contribution to achieving the goals of EE and energy sustainability - the number of workers required to perform key works and, finally, to evaluate the existing educational opportunities and propose optimal solutions in terms of redesigning existing programs and plans and programs and implementing new ones. The recommendations that this document should provide will be the cornerstone for making strategic decisions of all relevant stakeholders in the construction and education sectors for the purpose of establishing a system of education and training of the workforce in the areas of EE and OIE to achieve the goals that the Republic of Croatia has set for itself by 2030. in the building industry.

2.2. Methodology

In order to create the content for chapters 3 and 4, more than 40 different documents and data sources were analyzed. The list of documents that were analyzed is among the references and includes various strategies, national plans and programs, energy analyses, directives, laws and regulations. Of the sources and databases, the most important was the State Bureau of Statistics, but also the database of energy certificates. The analysis was made by the Regional Energy Agency North.

The analysis of vocational education was carried out by the Association of Construction Schools, which has 30 members of secondary schools that educate students in the field of Construction and Geodesy. The data were collected by the principals and teachers of these schools, who collected data from all schools in their counties. The data was collected through a survey that was distributed to all high schools in the Construction and Surveying department. The survey was designed to gather information on the number of students who completed, the number of students who enrolled and the number of students who are in the profession for the school years 2018/19, 2019/20, 2020/21 and 2021/22. The analysis covers 30 secondary schools that educate students in the construction professions from 18 counties. For the construction occupations, four-year (architectural technician, construction technician, construction technician for sustainable development and stonemasonry technician) and three-year occupations (mason, carpenter, facade worker, stonemason, roofer, insulator, rebar installer, dry construction fitter, sub-layer, tile setter) were analyzed. In the field of mechanical engineering and electrical engineering, the analysis includes 48 secondary schools that educate students in these professions from 17 counties. The occupations were analyzed: electrical technician (four-year) and three-year occupations heating and air conditioning installer, installer, fitter, electrical fitter, electrical fitter, gas fitter. As part of the CRO skills RELOAD project, a survey was sent to

78 secondary schools in order to identify the existing adult education system. Data were requested on the implementation of training/improvement for workers over a 4-year period, on the number of trainers who provide adult education, and their self-assessment of knowledge (whether training of trainers is necessary)

The methodology used to collect data on the skills that construction workers acquire through tertiary, higher education in Croatia involved a multi-step process. Due to the inconsistency of official registers containing relevant data on the number and area of expertise of higher education institutions in Croatia, the Faculty of Civil Engineering of the University of Zagreb had to rely on several sources to obtain data. The first step was to use the ISVU national database, which provides information on higher education institutions and study programs in Croatia. From this database, a list of faculties founded by public bodies, as well as some private institutions, was extracted. This list was used as a reference for contacting the faculty due to its credibility and the fact that the information it contains was verified and updated in 2023. Faculties in the fields of civil engineering, mechanical engineering, informatics and architecture were selected based on the list. Then the official websites of those faculties were reviewed in order to identify courses or subjects dealing with energy efficiency, renewable energy sources, digitization, green construction, sustainability, etc. After the relevant courses/subjects were identified, the main professors in those fields were contacted in order to gain insight into the curricula and the number of enrolled students. By contacting the main professors, the Faculty of Civil Engineering of the University of Zagreb gained valuable insight into the programs and courses offered, including the number of enrolled students and the specific skills developed. This information was crucial for understanding the level of education and training of students in these areas and the extent to which energy efficiency and renewable energy sources are integrated into curricula.

The methodology used to collect data on relevant construction skills projects in Croatia for construction workers included the use of online sources and national and European portals that provide information on EU-funded projects. The process was initiated by a thorough search of relevant internet databases, including the official websites of Croatian state agencies and the European Commission. This allowed us to identify the portals that were most relevant to our research. We then focused on two primary sources of information: the Croatian Agency for Small Business, Innovation and Investments (HAMAG-BICRO) and the European Structural and Investment Funds (ESIF) portal. The HAMAG-BICRO portal provides information on projects financed by the Government of the Republic of Croatia, while the ESIF portal provides information on projects financed by EU funds. These portals were selected because they provide a comprehensive list of projects relevant to the construction industry, including those related to construction skills and training. Using these portals, the University of Zagreb Faculty of Civil Engineering was looking for projects related to construction skills and training of construction workers. We used a combination of keywords and filters to narrow the search results and ensure we only identified projects relevant to our research. After identifying potential projects, we reviewed project descriptions and all available documentation to better understand the scope and focus of the project. This approach allowed us to identify a comprehensive list of projects that were relevant to our research and to obtain detailed information about the specific groups and construction skills that were developed or improved through these projects.

The methodology used for the analysis of barriers included the analysis and processing of data available on the Internet, including available national documents, as well as a review of data obtained from previous CROskills projects for comparison

and insight into the previous and current state. In addition, the Croatia Green Building Council, in order to gain an insight into the current real situation in the construction sector, conducted a short questionnaire among its members, contractors, manufacturers and others relevant to the research. The questionnaire was completed by 30 representatives who indicated the problems they face, which are key in creating strategies and guidelines for improving the qualifications of construction workers to achieve energy efficiency goals by 2030, which are also listed in the eighth chapter. The first meeting of the National Qualification Platform provided additional input to the already collected information. The conclusions of the working groups from the meetings that opened up some of the priority issues provided quality feedback for the direction of the document's development and served as a confirmation of all the previously mentioned analyses.

The methodology for collecting data on the identification of skills shortages in Croatia included contacting members of the Croatian Chamber of Trades and Crafts and sending questionnaires. The purpose of the questionnaire was to determine the structure of trades that perform construction work today, as well as the level of knowledge and motivation of tradesmen, directors and their employees about energy efficiency and new technologies and trends in construction. The questionnaire consisted of general questions about the trades and indicators of their work, such as size, types of jobs and number of workers. More detailed questions were asked about new technologies and their application in the context of energy efficiency in buildings. This included the level of knowledge of energy-efficient technologies, the proportion of work related to the direct installation of energy-efficient technologies or aimed at increasing energy efficiency, and the type of energy-efficient technologies used in everyday business. The questionnaire also examined the attitude towards the use of energy-efficient technologies and digitization. In addition, the questionnaire contained questions about artisans' attitudes towards worker education, preferred education modalities and attitudes about optimal worker education policies. It was also discussed about the views of craftsmen on the lack of qualified workers and the employment of foreign workers. The craftsmen gave an insight into the needs of their employees for the types of education and the necessary knowledge about certain technologies. The questionnaires were delivered to the craftsmen directly with a link to Google Forms. Several visits were also made in the form of educational round tables in order to increase the visibility of the project and to receive direct information from craftsmen and workers. Questionnaires were answered by workers and managers of various professions, including work on the outer envelope, electrical installations, gas, heating, water and air conditioning installations, dry construction, roofers/carpenters, carpenters, glass workers, and renewable sources (photovoltaic, cogeneration). By asking questions for each of the representative groups of craftsmen, an attempt was made to gain insight into the needs for capacities, knowledge and skills of workers in each of the mentioned sectors, which served as a basis for the approximation of skills at the sector level.

3. National policies and strategies to contribute to the EU 2030 energy and climate targets in buildings

3.1 National energy policies and strategies to meet the 2030 targets

In the Republic of Croatia, there are various instruments of energy policy, such as strategies and national plans, which are applied in order to achieve the goals of sustainability and reduction of greenhouse gas emissions in the building sector by 2030.

National goals for the share of renewable energy sources until 2030 are defined by the *Integrated National Energy and Climate Plan for the Republic of Croatia for the period 2021-2030* [8]. Table 1 shows all four goals, where the first and third indicative goals are presented in accordance with *Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action* [9] and *Directive (EU) 2018/2001 on the Promotion of the use of Energy from Renewable Sources* [10], and the second and fourth goals are presented in accordance with the Integrated National Energy and Climate Plan for the Republic of Croatia for the period 2021-2030.

Table 1 Indicative national targets for RES shares for Croatia (source: [11] [12])

RES share	2030 goal
In final energy consumption	39,4%
In final electricity consumption	63,8%
In final consumption in heating and cooling	47,8%
In final consumption in transport	14,0%

Table 2 shows the actually achieved shares of RES in gross direct energy consumption in the period from 2013 to 2021. The table shows only the shares that are important for the building sector (share in gross direct consumption of electricity and share in energy consumption for heating and cooling). The data source is the publication Energy in Croatia [8].

Table 2 Actual achieved RES shares in gross final energy consumption in Croatia (source: [8])

Indicator	2013	2014	2015	2016	2017	2018	2019	2020	2021
RES-E - RES share in final electricity consumption	42,1%	45,2%	45,4%	46,7%	46,4%	48,1%	49,8%	53,8%	53,5%
RES-H&C - RES share in final consumption in heating and cooling	37,3%	36,2%	38,6%	37,6%	36,6%	36,7%	36,8%	37,0%	38,0%

We can immediately see that the actual share of RES-E has grown noticeably from year to year, while the share of RES-H&C has grown much more slowly. Therefore, in order to achieve the goal of this indicator, the application of new effective technologies for increasing the production of RES in buildings, as well as construction and renovation techniques in buildings, must be accelerated.

As mentioned, there are various instruments in Croatia to achieve the goals of these indicators. Below is an overview and description of individual instruments at different levels.

3.1.1 Energy Development Strategy of the Republic of Croatia for the period until 2030 with a projection until 2050

Energy Development Strategy of the Republic of Croatia for the period until 2023 with a projection until 2050 [13] contains the goals of increasing energy efficiency and the share of use of renewable energy sources and reducing energy consumption in all sectors. The strategy represents a step towards the realization of the vision of low-carbon energy and ensures the transition to a new period of energy policy that ensures affordable, safe and high-quality energy supply without additional burden on the state budget within the framework of state subsidies and incentives. The strategy represents a wide range of energy policy initiatives, which will strengthen the security of energy supply, gradually reduce energy losses and increase energy efficiency, reduce dependence on fossil fuels, increase domestic production and use of renewable energy sources.

In the building sector, the Strategy considers increasing energy efficiency through energy renovation of the building stock at an average annual rate of 1.6% (in one scenario) or 3% (in another scenario). A more precise renovation plan is dealt with in the *Long-term Strategy for National Building Stock Renovation by 2050* [14].

As part of the energy transition, an increase in the use of energy from RES and diversification of the used energy sources is expected. Thus, in scenario S2, the use of RES increases by 49% by 2030, and by 81% by 2050, while in scenario S1, it increases by 42% by 2030, and by 93% by 2050. It should be noted here that in 2017, the Republic of Croatia achieved a share of RES of 27.3% in gross direct consumption, while the EU average was 17.5%. With the achieved share in 2017, the Republic of Croatia exceeded the goal set by 2020, which is a 20% share of RES in gross direct consumption.

3.1.2 Integrated National Energy and Climate Plan for the Republic of Croatia for the period 2021-2030

Integrated National Energy and Climate Plan for the Republic of Croatia for the period 2021-2030 [8] builds on existing national strategies and plans. It provides an overview of the current energy system and the situation in the field of energy and climate policy. It also provides an overview of the national goals for each of the five key dimensions of the energy union and the appropriate policies and measures to achieve these goals, and for which an analytical basis should be established. In this plan, special attention is paid to the goals until 2030, which include the reduction of greenhouse gas emissions, energy production from renewable sources, energy efficiency and electric power interconnection. In this way, it will be ensured that the Integrated National Energy and Climate Plan is in accordance with the goals of sustainable development and that it contributes to them in this sense.

Table 3 shows the investment plan in the building sector to achieve the set energy goals.

Table 3 Estimation of investments in building sector until 2030 and until 2050 (source: [8])

Area of investment	2021–2030	2031–2050
Heating facilities	0,08 bill. €	0,16 bill. €
Building sector - energy renovation of buildings	1,73 bill. €	3,70 bill. €
Building sector - nZEB new constructions	5,08 bill. €	13,86 bill. €

As for the building sector, *Integrated National Energy and Climate Plan for the Republic of Croatia for the period 2021-2030* in many places in its text refers to or refers to data from the Long-term Strategy for National Building Stock Renovation by 2050, but it also contains valuable data on the expected increase in the share of

renewable energy sources in the building sector, which we used for the purpose of creating this document.

3.1.3 National Energy Efficiency Action Plan for the period 2022-2024

National Energy Efficiency Action Plan for the period 2022-2024 [15] is made based on the provisions of Article 8 *of the Act on Energy Efficiency* [16]. At the beginning, it presents an overview and evaluation of energy consumption in Croatia through the movement of primary energy consumption and direct (final) energy consumption in the period from 2014 to 2020. In the period from 2014 to 2020, a decline in primary energy consumption was observed, but a continuous increase in direct energy consumption. This trend is the result of the penetration of renewable energy sources and the improvement of the efficiency of production facilities in the energy production/transformation sector, while in direct consumption the effect of the implementation of energy efficiency measures could not neutralize the effect of economic trends and the increase in general consumption. Then, the achievements of the energy efficiency goals set in the period from 2014 to 2020 were analyzed. The national framework goal of improving energy efficiency expressed in absolute values of primary energy consumption (448.5 PJ) and direct (final) consumption (291.3 PJ) in 2020 was achieved - in 2020, Croatia achieved 18.7% less primary energy consumption (364.6 PJ), i.e. 7.5% lower immediate energy consumption (269.5 PJ) compared to the target. However, these data should be interpreted carefully, because energy consumption in 2020 was significantly affected by the COVID-19 pandemic, especially in the direct energy consumption segment.

As part of this plan, national goals in the field of energy for the period from 2021 to 2030 are cited and a number of measures are described, aligned with the *Integrated National Energy and Climate Plan for the Republic of Croatia for the period 2021-2030* [8] and *the Long-term Strategy for National Building Stock Renovation by 2050* [14]. Some of these measures are, for example, energy renovation programs for multi-apartment buildings, family houses, public sector buildings and buildings that have the status of cultural property. There are also decarbonization of the heating system in the public sector, education in the field of energy efficiency, promotion of nZEB construction and renovation standards, increasing the efficiency of the heating system, increasing energy efficiency and the use of RES in production industries.

3.1.4 Long-term Strategy for National Building Stock Renovation by 2050

Long-term Strategy for National Building Stock Renovation by 2050 [14] was created with the purpose of supporting the renovation of the national fund of residential and non-residential buildings, public and private, and the transformation of the existing building fund into an energy-efficient and decarbonized building fund by 2050. It sets long-term goals for the renovation of the national building stock and provides an estimate of the necessary investments. The main goal of the Long-Term Strategy, based on the established economic-energy optimal model of building renovation, is to identify effective measures for long-term stimulation of cost-effective integral renovation of the national building fund of the Republic of Croatia until 2050, which includes all buildings of the residential and non-residential sectors.

The renovation strategy also sets goals for energy and comprehensive renovation, for increasing the share of renewable energy sources, for introducing innovations and smart technologies that enable buildings to support the overall decarbonization of the economy and the promotion of electromobility. The mentioned measures will contribute to achieving the ambitious climate goal of reducing greenhouse gas emissions by 55% by 2030, compared to the situation in 1990, that is, according to the Renovation Wave initiative, it is necessary to reduce greenhouse gas emissions from buildings by 60%. To achieve the goals set by the Strategy, the most important measures include the implementation of national energy renovation programs for different types of buildings.

The strategy envisages a gradual increase in the current renovation rate (2014-2019) of 0.7% of the total area of the building fund, or 1.35 million m² per year. The target renewal rate will increase from 1% in 2021 and 2022, 1.5% in 2023 and 2024, 2.0% in 2025 and 2026, 2.5% in 2027 and 2028, 3 % in 2029 and 2030, then to 3.5% from 2031 to 2040 and to 4% from 2041 to 2050.

In view of the extraordinary circumstances caused by the earthquake that hit Zagreb and its surroundings on March 22, 2020, this strategy will serve to further emphasize the issue of the risk of increased seismic activity and the connection of seismic and energy restoration in order to achieve synergy through the simultaneous development of these two processes.

The energy renovation of buildings in the future period requires large investments, and for co-financing it will be necessary to use all available sources of financing, such as ESI funds, the Recovery and Resilience Fund, national funds from the Environmental Protection and Energy Efficiency Fund, private investments by ESCO companies, investments from the system of obligations of energy savings, preferential loans, guarantees, PPP, etc.

Some of the thematic units contained in *the Long-term Strategy for National Building Stock Renovation by 2050* [14] are as follows:

- The overview of the national building fund of the Republic of Croatia includes data on the number, area, and construction and energy characteristics of the national building fund divided by purpose into four categories (apartment buildings, family homes, public buildings and commercial buildings).
- The analysis of the key elements of the building renovation program includes the analysis of technical possibilities for energy renovation by applying energy efficiency measures and renewable energy sources, the analysis of technical possibilities of the heating system and the determination of possible models of sustainable building renovation and estimates of expected energy savings.
- The review of policies and measures aimed at specific problem areas includes a review of the national fund of buildings with the worst properties and measures or programs for energy renovation of these buildings, dilemmas of conflicting interests of lessors and lessees; market deficiencies; measures to combat energy poverty; promotion of skills, new techniques and technologies in the field of almost zero energy buildings and energy renovations and requirements related to the sustainability of urban environments and electromobility.
- Policies and measures aimed at all public sector buildings include an overview of existing measures and obstacles for the energy renovation of public sector buildings, cultural heritage buildings and buildings owned and used by the armed forces of the Republic of Croatia.
- 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 include a review of policies and measures to promote smart technologies and well-connected buildings and a review of existing policies and measures to promote skills and education in the construction sector and energy efficiency sector.
- A plan with measures, measurable indicators of progress and indicators for key points 2030, 2040 and 2050, which includes a long-term plan with measures for the decarbonization of the national building stock by 2050 and measurable indicators of progress. It also includes tentative relevant key points for 2030, 2040 and 2050 and a contribution to the tentative national goal of improving energy efficiency.
- The assessment of the expected energy savings and wider benefits includes the assessment of energy savings using the bottom-up method for each proposed measure of energy renovation of buildings and the assessment of the reduction of

CO_2 emissions; contribution to the achievement of EU energy efficiency goals; macroeconomic effects on GDP, employment and the state budget; assessment of other benefits of the energy renovation of the national building fund, such as real estate values and those related to the reduction of health risks, energy poverty and energy supply. Investments in the integral renovation of buildings create far wider economic benefits than just energy savings and improvements in the quality of housing and work.

Concrete data from this strategy are processed in more detail and presented in chapter 4. *Statistics from the field of buildings and energy*.

3.1.5 Energy Renovation Program of Multi-apartment Buildings for the period until 2030

Energy Renovation Program of Multi-apartment Buildings for the period until 2030 [17] is adopted on the basis of the *Construction Act* [18], in order to fulfil the strategic medium-term goal set in *the Long-term Strategy for National Building Stock Renovation by 2050* [14] according to which the energy renovation rate of the total building stock is planned to gradually increase from 0.7% per year (1,350,000 m²/year) to 3% in 2030, i.e. the goal is 30.84 million m² of renovated buildings by 2030. The program includes the energy renovation of multi-apartment buildings, both undamaged and those damaged in the earthquake, with the aim of reducing energy consumption and increasing the safety and resistance of existing multi-apartment buildings to fire and earthquakes.

The program refers to the segment of multi-apartment buildings, which represent about 35% of the total housing stock, or about 27% of the total building stock in Croatia. According to this program, about 32% of the total energy supplied to the household sector is spent on multi-residential buildings, and about 80% of that is spent on thermal needs, that is, space heating and cooling and the preparation of domestic hot water. In the structure of energy consumption, the dominance of firewood is visible with almost 50% in the entire household sector, while for multi-apartment buildings this share is still smaller and amounts to around 35%. The program states that in multi-apartment buildings firewood is even the most represented energy source (ahead of natural gas and centralized heating systems) and that this indicates the need to replace such systems with more modern systems that also use renewable energy sources. The focus of the Program is on buildings with the worst energy properties (energy class D according to $Q''_{H,nd}$ or worse in continental Croatia and C or worse in coastal Croatia). About 34% of multi-apartment buildings in continental Croatia belong to buildings with the worst properties, while in coastal Croatia there are about 30% of such buildings. At the same time, these buildings often have poor structural properties.

In total, in the period until 2030, around 6.3 million m^2 in multi-apartment buildings should be renovated. On an annual level, this would mean the renovation of an average of about 700,000 m^2 in the period from 2022 to 2030, which would achieve the goals of the Long-term strategy for the renovation of the national building fund of the Republic of Croatia until 2050.

In the program, it is estimated that there are about 50 million m^2 of usable area of multi-apartment buildings in Croatia. 65% of the buildings are located in the continental part, while around 35% are in the coastal part of Croatia. Most of the buildings were built before 1987, which means that they use approximately 200-250 kWh/m^2 of heat energy for heating. By applying measures to increase energy efficiency, it is possible to reduce the consumption of these buildings to 50 kWh/m^2, or even fivefold.

Based on this program, the first calls for the allocation of grants for the renovation of multi-apartment buildings have already started. The invitations support measures of energy efficiency and the use of renewable energy sources that should result in a saving of the annual energy required for heating (QH,nd) (kWh/year) of at

least 50% compared to the state before the renovation at the level of an individual multi-apartment building, through an integrated approach, with the application of measures to increase the seismic resistance of the building and safety in case of fire, as well as ensuring healthy indoor climate conditions.

3.1.6 Energy Renovation Program of Public Sector Buildings for the period until 2030

Energy Renovation Program of Public Sector Buildings for the period until 2030 [19] is adopted on the same basis as the previously described program.

The program refers to the segment of public sector buildings, which represent 27.4% of the total non-residential stock, or 9.5% of the total building stock in Croatia. The focus of the program is on buildings with the worst energy properties (energy class $Q_{,H,nd}$ or worse in continental Croatia and C or worse in coastal Croatia).

In total, in the period until 2030, over 2.9 million m^2 in public sector buildings should be renovated. On an annual level, this would mean the renovation of an average of about 325,000 m^2 in the period from 2022 to 2030, which would achieve the goals of the Long-term Strategy for National Building Stock Renovation by 2050.

3.1.7 Energy renovation program of buildings that have the status of cultural property for the period until 2030

The goal of *the Energy Renovation Program of Cultural Property Buildings for the period until 2030* [20] is the initiation of a comprehensive energy renovation, ensuring the protection and preservation of cultural heritage and thereby improving such buildings that are national symbols and symbols in the visions of cities. Namely, according to the previous programs, buildings with the status of cultural heritage, mostly could not meet the high energy saving criteria due to their specificities and conservation measures, and for these reasons they could not be energetically renovated.

Protected buildings in the sense of this program can be classified into two categories: individually protected cultural assets (individual buildings and construction complexes) and buildings located within a protected cultural-historical complex.

The requirements for achieving savings in these buildings are much lower compared to other buildings. By applying the foreseen measures, it is necessary to achieve a minimum saving of 20% of the annual required thermal energy for heating ($Q_{h,nd}$) or a minimum saving of 20% of the annual primary energy (E_{prim}).

The program estimates that there are 102,615 buildings within cultural and historical units in Croatia, of which 44,889 are in continental Croatia and 57,726 are in coastal Croatia. Within this number there are also 1,950 individual buildings that have the status of cultural heritage. For buildings within cultural-historical units that do not have the status of individual cultural heritage, there is no information on classification according to purpose and period of construction. In the database of the Energy Management Information System, EMIS (https://isge.hr) [21], the total usable area of public buildings that have a certain degree of conservation protection (individually protected cultural property or as part of a protected cultural-historical unit) is recorded. Out of 1,971,715.35 m^2, 1,532,362.34 m^2 are in continental Croatia , and 439,353.01 m^2 are in coastal Croatia.

By analyzing the data from the Energy Management Information System and applying it to the total national fund of public buildings based on [14], it was estimated that the national fund of public buildings that are the subject of this program amounts to 2,302,158 m^2 . Also, it was estimated that in the Republic of Croatia, the national stock of multi-apartment buildings that are the subject of this program is 9,247,069 m^2 , while the stock of family houses that are the subject of this program is 14,468,001 m^2 . Following on from all of the above, it is estimated that the total national fund of buildings that are the subject of this program is 26,017,228 m^2.

3.1.8 Previous results of energy renovation of buildings financed through public calls

In Croatia, buildings consume more than 40% of the total energy consumption, and most buildings belong to energy class C, D or E. In the last few years, we have seen a steady increase in public and residential buildings where energy renovation projects are carried out. The European Commission approved the Operational Programme Competitiveness and Cohesion on December 12, 2014, which enabled the Republic of Croatia to use funds from *the European Fund for Regional Development and the Cohesion Fund*, which are an integral part of the European Structural and Investment Funds (ESI Funds).

Out of a total of 311 million euros, which is within *the Operational programme competitiveness and cohesion 2014 – 2020* intended for the energy renovation of public and residential buildings, 95% of the total allocation has been reserved through *the European Fund for Regional Development* since 2015, from when the first invitations of the Ministry of Construction and Spatial Planning were published until the last, fifth in a row, of the Invitation for Energy Renovation that was published at the end of 2017.

If we assume that the average intensity of co-financing of the investment was around 50%, that the average acceptable cost of energy renovation was around 250 EUR/m^2 (at the first call 200 EUR, and at the last 331 EUR), we arrive at the approximate data that it was a total of about 2.5 million m^2 of the gross construction area of buildings (residential and non-residential, i.e. public purpose buildings) were renovated with the funds. It was not possible to obtain accurate data for the purpose of this analysis.

3.2 Planned activities in relation to the implementation of the EPBD and the RES Directive

Two important directives have been completely transposed into the Croatian legal system - *Directive on the Energy Performance of Buildings 2010/31/EU (EPBD)* [22] and *Directive 2012/27/EU on Energy Efficiency* [23]. The directives were transposed so that their provisions were incorporated into the laws and regulations mentioned here. It is worth noting that both directives were partially amended in 2018 by *Directive (EU) 2018/844 of the European Parliament and of the Council* [24] i.e. harmonized with the new circumstances in the European Union and in accordance with practical experience after a review of implementation (almost all changes refer to *Directive 2010/3 /EU*). Among other things, *Directive 2010/31/EU* now requires that each member state must adopt a long-term renovation strategy to support the renovation of the national stock of residential and non-residential buildings, public and private, to an energy-efficient and decarbonized building stock by 2050. The most important change occurred with areas of transfer of guidelines and requirements for nearly zero energy buildings.

According to the new *Directive (EU) 2018/2001 on the Promotion of the use of Energy from Renewable Sources* from December 11, 2018 [10], all member states are obliged to increase the share of RES for heating and cooling by 1.3 percentage points per year, or 1.1 percentage points per year if waste heat is not used, as an annual average for the period from 2021 to 2025 and the period from 2026 to 2030, in relation to this share in 2020, expressed as a share of final consumption and according to the methodology prescribed in [8]. Focusing on the district heating and cooling sector, an increase in the share of RES is required at the level of 1.0 percentage points per year in the period from 2021 to 2025 and in the period from 2026 to 2030, compared to this share in 2020, year, expressed as a share of final consumption and according to the methodology described in the same document.

3.3 National legislative framework in the building sector and RES obligations in buildings

The legislative framework of the Republic of Croatia in the field of buildings and energy efficiency consists of a series of laws and regulations that regulate different

types of construction and renovation of buildings in general and in terms of increasing energy efficiency. The Republic of Croatia is a member of the European Union, its legislative framework is harmonized with directives and regulations, ie the acquis of the European Union, and it is obliged to continue harmonizing its laws and regulations with the European legal system.

The main legal act in the field of construction and building sector is the *Construction Act* [18] which prescribes conditions for the construction, reconstruction and demolition of buildings and regulates issues related to safety, health and environmental protection during the construction and use of buildings. Special attention in the law is devoted to the energy efficiency of buildings, that's why one of the important requirements for buildings that are ensured in design and construction is precisely energy saving and thermal protection. The law stipulates the application of minimum requirements for energy efficiency during the construction of new buildings and the renovation of existing ones. Accordingly, the obligation of energy certification of buildings is prescribed, as well as sanctions for non-compliance with energy requirements. The law also requires investors to take into account the use of renewable energy sources when designing and constructing buildings, as well as to use construction materials that are environmentally friendly and do not harm the environment. This law defines, among other things, a nearly zero-energy building. Amendments to the *Construction Act* related to the adoption and implementation of the *Long-term Strategy for National Building Stock Renovation by 2050* [14], regulate the promotion of electromobility through the installation of infrastructure for charging electric vehicles in buildings and in parking lots next to buildings, the simplification of regular inspections of the heating and cooling systems or air conditioning in buildings, adjustment and monitoring of technical building systems, defining requirements related to the installation of self-regulating devices, and building automation and management systems, as well as changes in the system of issuing authorizations for energy certification of buildings.

Technical Regulation on Rational use of Energy and Thermal Protection in Buildings [25] directly derives from the *Construction Act* and is one of the most important regulations in the building sector. It prescribes:

- detailed technical requirements regarding the rational use of energy and thermal protection of the construction part of the building, technical systems of heating, ventilation, cooling, air conditioning, preparation of domestic hot water and built-in lighting that must be met during the design and construction of new buildings
- requirements regarding the rational use of energy and thermal protection that must be met during the design, significant renovation and reconstruction of existing buildings
- the minimum mandatory share of renewable sources in the total energy consumption of the building, the criteria for nearly zero energy buildings, and with the aim of optimizing the energy use of the building's technical systems, the requirements for building automation and management systems and other requirements related to the energy efficiency of the building were determined.

According to the mentioned *Technical Regulation*, a residential building and non-residential building with nearly zero energy is a building where the following conditions are met:

- the annual required heat energy for heating per unit area of the usable area of the heated part of the building, $Q''_{H,nd}$ [kWh/(m^2 a)], is not greater than the permitted values determined in Table 8 from Annex B of the *Technical Regulations*, in which for each type of building (apartment, office, non-residential, etc.), different energy levels are determined according to the characteristics and purpose of these buildings
- annual primary energy per unit area of the useful area of the heated part of the building, E_{prim} [kWh/(m^2 a)], which includes the energies listed in Table 8, and is

not higher than the permitted values determined in Table 8 from Annex B of the *Technical Regulations*, where levels are also determined according to the characteristics and purpose of those buildings

- the building meets the requirements regarding the application of renewable energy sources so that at least 30% of the annual delivered energy of the building for the operation of technical systems in the building is met from renewable energy sources and in the case where at least 60% of the annual energy delivered for the operation of technical systems in the building is met from an efficient centralized heating system, i.e. an efficient system of centralized heating and cooling, which uses at least 50% of renewable energy, 50% of waste heat, 75% of heat obtained from cogeneration or 50% of a combination of such energy and heat
- the building must meet the airtightness requirements (Blower door test) from the provisions of Article 26 of the *Technical Regulation*, which are proven by testing on a newly constructed or reconstructed existing building according to HRN EN ISO 9972:2015 [19], determination method 1, before the technical inspection of the building; for residential buildings that have more than one apartment, the airtightness requirement must be met for each apartment.

In the field of energy efficiency of buildings*, the Act on Energy Efficiency* is important [16]. *The Act on Energy Efficiency* of the Republic of Croatia prescribes a series of measures to improve the energy efficiency of buildings in Croatia. It aims to rationalize energy consumption in buildings, reduce greenhouse gas emissions and contribute to sustainable development. This law prescribes minimum requirements for construction in terms of thermal protection, as well as requirements for heating, ventilation, cooling and air conditioning systems. The act obliges state and public institutions to apply energy efficiency measures in their buildings, and prescribes the obligation to use renewable energy sources, such as solar and geothermal energy or biomass, during the construction and renovation of buildings. Also, the Act stipulates that when constructing new buildings or renovating existing buildings, passive energy efficiency measures are applied, such as thermal insulation, use of natural light and ventilation.

Regulation on Contracting and Implementation of Energy Service in the Public Sector derives from the *Act on Energy Efficiency* [27]. This Regulation determines the rules for contracting energy services in the public sector, i.e. it regulates the market of energy service providers (ESCO). Energy service is an instrument by which the customer can significantly reduce the investment costs of energy renovation, since the energy service provider finances the investment, and the cost of the investment is financed by regular payments by the customer for realized and verified energy savings during the contractual period.

The Ministry of Physical Planning, Construction and State Assets is primarily responsible for the realization of energy efficiency goals, i.e. the national energy efficiency policy, and within the Ministry, the Directorate for Energy Efficiency in Construction, Projects and Programs of the European Union is directly responsible. As part of the Directorate, there is also a Sector for Implementation of National Recovery and Resilience Plan and European Union Assistance Programmes.

Another important law is *the Law on Chamber of Architects and Chambers of Engineers in Construction and Spatial Planning* [28] considering that this analysis also considers the needs for the number of employed "white collar" workers (highly educated engineers). This Law regulates the basic organization, scope, public powers and membership of the Croatian Chamber of Architects, the Croatian Chamber of Civil Engineers, the Croatian Chamber of Mechanical Engineers and the Croatian Chamber of Electrical Engineers (the Chamber).

Directive (EU) 2018/2001 on the Promotion of the use of Energy from Renewable Sources [10] has also been transferred to our legal system. Among other things, the directive includes a binding general EU goal for 2030 of at least 32% of energy from renewable sources, and in the heating and cooling sector an annual increase of 1.3 percentage points

in the share of renewable energy in that sector. The directive was transposed through *the Act on Renewable Energy Sources and High-efficiency Cogeneration* [29] which regulates the planning and promotion of the production and consumption of electricity produced in production plants that use renewable energy sources and high-efficiency cogeneration, as well as promotion measures for the production of electricity. Among other things, the act encourages building owners to use renewable energy sources such as solar panels or heat pumps for heating and cooling buildings. New public buildings and existing public buildings on which large-scale renovation work is being carried out, at the national, regional and local level, serve as an example in fulfilling the provisions of this Act. Owners of public buildings can fulfil this obligation by complying with the provisions on nearly zero energy buildings determined by the regulation governing the construction area or by ensuring that the roofs of public or private-public buildings are used by third parties for devices that produce energy from renewable sources. In addition, it stipulates that households are eligible to participate in the renewable energy community provided that their participation is not their primary commercial or professional activity. This creates new opportunities for increasing the production and use of RES in buildings.

Several other important ordinances derive from the Construction Act:

- *Ordinance on Simple and Other Buildings and Works* [30] which determines simple and other buildings and works that can be built or carried out without a building permit in accordance with the main project and without a main project, buildings that can be removed without a removal project and prescribes the obligation to report the start of construction and professional supervision of the construction of these buildings, i.e. the execution of works. This Ordinance is particularly important because it facilitates the energy renovation of buildings in cases where the renovation does not affect the basic requirements for the building.
- *Ordinance on Energy Audit of Buildings and Energy Performance Certification* [31] as well as *the Ordinance on Inspection of Energy Performance Certificates* [32] and reports on the regular inspection of the heating system and the cooling or air conditioning system in the building.
- *Ordinance on Authorized Persons for Energy Performance Certification* [33], energy audit of the building and regular inspection of the heating system and the cooling or air conditioning system in the building.

Significant progress has been made in the field of energy audit of buildings in the last ten years. In the previous analysis, it was stated that from 2010 to 2013, more than 6,000 building energy certificates were issued. In April 2023, the number of issued certificates was more than 130,000. This number was obtained directly from *the Information System of Energy Certificates* (https://eenergetskicertifikat.mgipu.hr) [34], which did not exist 10 years ago (used since October 1, 2017). In the same system, it is also visible that in the same month there were 570 persons authorized to certify buildings in Croatia. In addition, there is also a list of institutions that have consent to carry out the certifier training programs (seven institutions).

It is also worth mentioning that the *Ministry of Physical Planning, Constructiona and State Assets* publicly announced a program for determining the energy performance of a building - Energy Auditor, developed by the University of Zagreb, Faculty of Organization and Informatics. Persons authorized for energy certification, energy inspection of the building and regular inspection of the heating system and the cooling or air conditioning system in the building can download and use the program for determining the energy performance of the building free of charge.

3.4 Envisaged contribution of the building sector to the 2030 targets

According to *the Integrated National Energy and Climate Plan for the Republic of Croatia for the period 2021-2030* [8] cumulative energy savings in the period 2021-2030 should amount to a total of 125.3 PJ or 34,805 GWh of energy.

According to the same source, energy renovation of buildings based on all planned energy renovation programs and related measures should contribute to this goal by 2030 with 35.52 PJ or 9,867 GWh of realized savings.

Below is a summary of the planned measures and programs in which the building sector will contribute to the achievement of the 2030 goals [8]:

- Measure OIE-1 *Information, education and capacity increase for the use of RES* - Promotion of the use of systems in buildings (photovoltaic systems, solar thermal systems, heat pumps, stoves and biomass boilers). Investment of €700,000/year.
- Measure OIE-3 *Encouraging the use of RES for the production of electricity and heat* - Financial measure - Providing financial incentives for the development of projects for the use of RES for the production of electricity and heat. Encouraging the use of RES for the production of electricity and thermal energy will be implemented at the national level. An investment of 1 billion EUR until 2030.
- ENU-3: *Energy renovation program of multi-apartment buildings* - Financial measure; implementation from 2021 to 2030. It is planned to renovate around 520,000 m^2 of multi-apartment buildings per year. Savings were calculated assuming energy renovation of buildings to the level of satisfactory legal requirements on the rational use of energy and thermal protection in buildings, according to the periods of building construction. The annual savings amount is 0.148 PJ. The estimated investment cost in the period 2021-2030 is EUR 1.035 billion from ESI funds in the amount of up to 60% of the justified costs. Effect: Reduction of heat needs and energy consumption in multi-apartment buildings and increase in the use of renewable energy sources and consequently reduction of CO_2 emissions; estimated savings in 2030 1.48 PJ (35.40 ktoe); estimated reduction of CO_2 emissions in 2030 40.74 ktCO_2e; cumulative energy savings in the period 2021-2030 8.15 PJ (194.70 ktoe); cumulative reduction of CO_2 emissions in the period 2021-2030 232.17 ktCO_2e.
- ENU-4: *Energy renovation program of family houses* - Financial measure; implementation in 2021 -2030. It is planned to renovate around 350,000 m^2 of family houses per year. Savings were calculated assuming energy renovation of buildings to the level of satisfactory legal requirements on rational use of energy and thermal protection in buildings, according to the periods of building construction. Annual savings amount to 0.191 PJ. Estimated investment cost in the period 2021-2030 is EUR 697 million of funds from the EPEEF in the amount of up to 60% of the justified costs of equipment and energy renovation works. Effect: Reduction of heating needs and energy consumption in family homes and increase in the use of RES and consequently reduction of CO_2 emissions; estimated savings in 2030 1.91 PJ (45.60 ktoe); estimated reduction of CO_2 emissions in 2030 52.57 ktCO_2e; cumulative energy savings in the period 2021-2030 10.50 PJ (250.80 ktoe); cumulative reduction of CO_2 emissions in the period 2021-2030 299.12 ktCO_2e.
- ENU-5: *Energy renovation program of public sector buildings* - Financial measure; implementation in 2021 -2030. It is planned to renovate around 350,000 m^2 of public buildings per year. Savings were calculated assuming energy renovation of buildings to the level of satisfactory legal requirements on rational use of energy and thermal protection in buildings, according to the periods of building construction. Annual savings amount to 0.169 PJ. Estimated investment cost in the period 2021-2030 is EUR 1.16 billion of funds from ESI funds. Effect: Reduction of heating needs and energy consumption in public sector buildings and increase in the use of renewable energy sources and consequently reduction of CO_2 emissions; estimated savings in 2030 1.69 PJ (40.40 ktoe); estimated reduction of CO_2 emissions in 2030, 46.52 ktCO_2e; cumulative energy savings in the period 2021-2030 9.30 PJ (222.20 ktoe); cumulative reduction of CO_2 emissions in the period 2021-2030 264.93 ktCO_2e

- ENU-6: *Energy renovation program of buildings with the status of cultural heritage* - Financial measure; implementation in 2021 -2030. Individually protected cultural heritage (individual buildings and construction complexes) and buildings located within a protected cultural-historical complex. Total investment: 1.81 billion EUR, the sources of grant funding are EU Funds and funds collected through Monument Annuity. Average annual renewal rate (%): 3.5. Total renovated area (m^2): 8,975,943. Energy savings (GWh): 5,073,234.38. Financial savings (KN): 1.393 billion. Reduction of CO_2 emissions (kt): 709.02.

3.5 Provisions on buildings within the National Recovery and Resilience Plan

In *the National Recovery and Resilience Plan* [35] the building sector is dealt with as the 6th Initiative - Renovation of buildings: decarbonization, i.e. comprehensive renovation of residential and non-residential buildings - private and/or public buildings, application of high-efficiency alternative systems, ensuring healthy indoor climate conditions. In addition, for the first time European funds will be used to finance the energy renovation of buildings with the status of cultural heritage, which were not covered by these funds in Croatia until now. The buildings damaged by the earthquake will also be included in the renovation. The total estimated value of the investment will be up to EUR 789 million. In addition to the renovation, there will also be an increase in knowledge about green jobs and the adjustment of the workforce in the area, as well as the integration of the concepts of green infrastructure and circular management of space and buildings (for which EUR 5.3 million will be allocated from this amount). The energy renovation rate provided in this plan will follow the rate already provided in the Long-term Strategy for National Building Stock Renovation by 2050 (achieving 2% of the renovated area of buildings until 2026).

3.6 National policies and strategies in the building sector in the field of continuing education and training

3.6.1 National policies and strategies related to green skills and jobs

The National Action Plan for Development of Green Skill Jobs Related to Energy and Post-Earthquake Reconstruction [36] was adopted in Croatia. Since the lack of a large number of workers with professional competences has been recognized, this plan provides the basis for increasing and improving knowledge and skills in the context of green jobs related to the process of energy renovation and reconstruction after an earthquake, and improves green skills in the same context, and defines activities related to higher education, lifelong education and connecting education and the labor market.

At the beginning of 2023, the Agency for Vocational Education and Training and Adult Education (AVETAE) published newly developed programs for the acquisition of green skills, which are available for download by interested educational institutions. So far, 7 education programs have been published for the acquisition of micro-qualifications in the following areas of building sector: Connection and commissioning of heat pumps, Installation and connection of solar thermal systems and collectors, Installation and connection of biomass boilers, Maintenance of biomass boilers, Maintenance of solar thermal systems, Environmental protection in the maintenance of residential and commercial buildings, Maintenance of power electronics for renewable energy sources.

In Croatia, there is a Database of certified installers of renewable energy sources (at https://einstalaterioie.mgipu.hr) for monitoring the qualification program for installers of renewable energy systems in the field of photovoltaic systems, solar thermal systems, shallow geothermal systems and heat pumps and smaller boilers and biomass stoves, as well as training program providers authorized by the Ministry

of Physical Planning, Construction and State Assets. Currently, only 545 certified installers of renewable energy source systems for photovoltaic systems are registered in the Database, while the database is empty for other installers. In the Database, you can see schools that implement programs for the implementation of training programs for certified installers, that is, a list of formal adult education programs equivalent to the training program. In relation to this, there are four Ordinances on conditions and standards for determining the quality system of services and works for the certification of installers of renewable energy sources, each Ordinance for one of the mentioned areas, namely:

- *Ordinance on conditions and standards for determining the quality system of services and works for the certification of installers of renewable energy sources - photovoltaic systems* (Official Gazette 56/15) [1]
- *Ordinance on conditions and criteria for determining the quality system of services and works for the certification of installers of renewable energy sources - solar thermal systems* (Official Gazette 33/15, 56/15, 12/17) [2]
- *Ordinance on conditions and criteria for determining the quality system of services and works for the certification of installers of renewable energy sources - smaller boilers and biomass stoves* (Official Gazette 39/15, 56/15, 12/17) [3]
- *Ordinance on conditions and standards for determining the quality system of services and works for the certification of installers of renewable energy sources - shallow geothermal systems and heat pumps* (Official Gazette 56/15, 12/17) [4]

3.6.2 Implementation of the European Qualifications Framework (EQF) and other EU education and training policies in the building sector

In Croatia, there is *an Act on the Croatian Qualification Framework* [37] which determines the Croatian qualification framework, and which determines the connection of the national framework with the European Qualifications Framework and the Qualification Framework of the European Higher Education Area and indirectly with the national qualification systems of other countries. The act determines that qualifications are classified according to levels and types, which can be complete or partial, and eight levels of sets of learning outcomes have been established. Thus, for example, level 2 represents qualifications obtained by completing vocational and artistic training, and level 3 qualifications obtained by completing secondary school education lasting less than three years, etc. The act is general and there are no special provisions related to the building sector. Secondary vocational education is regulated by the *Act on Vocational Education* [38], and adult education by the *Act on Education of Adults* [39]. The last act covers the implementation of formal programs and the awarding of qualifications at levels 1, 2, 3, 4, 4.1 and 4.2. and at level 5 of the Croatian Qualifications Framework in the part that refers to vocational specialist training that were acquired through formal and informal learning.

Integrated National Energy and Climate Plan for the Republic of Croatia [8] foresees the implementation of the educational measure "Education in the field of energy efficiency" in the period from 2017 to 2030. Further implementation of the system of continuous training and certification of construction workers through authorized CROSKILLS training centers is planned, according to the *Ordinance on education and certification system of construction workers* working on the installation of building components which affect the energy efficiency of buildings [5]. The national plan envisages the implementation of educational activities focused on the principles of green construction, and the activities in the previous period will create a Guide and guidelines on green and sustainable construction and guidelines for the Croatian Green Building certificate. The executive body for the implementation of the activity is the Agency for Vocational Education and Training and Adult Education, in cooperation with the partners of this project, the Faculty of Civil Engineering in Zagreb and the Croatia Green Building Council. The aforementioned Ordinance [5] on the other hand, prescribes the conditions and standards for the certification of con-

struction workers who install parts of the building that affect energy efficiency, the professional training and work experience required for joining the Training Program, the content and method of conducting the Training and Knowledge Assessment Program, and professional development.

3.7 Other policies and strategies related to the building sector

In Croatia, there are regulations related to the application of information and communication technology in construction and architecture.

For example, *the Construction Act* [18] stipulates that technical documentation for the constuction of objects can be prepared in electronic form and that it can be submitted to the responsible authority in electronic form via the ePermit system (with electronic signature), and special conditions, connection conditions and confirmation of the main project are determined and issued as electronic documents. The Ministry of Physical Planning, Construction and State Assets manages *the Physical Planning Information System* (https://ispu.mgipu.hr) [40], in which there are digitized services such as eRealEstate, eCatalog, ePlans, ePermits, eArchive, eConference, eInspection, eInvestments, eConstructionLog and eEnergyCertificate. The goal of these services is to ensure better availability of public services to citizens, reduce the administrative burden and costs for citizens, and achieve greater economy and efficiency in the work of public administration.

Preferred technologies that speed up the building design process and improve the process on the construction site are BIM (Building Information Modeling) and digital twins (Digital Twins). BIM is a collaborative process of creating project documentation through the creation of a virtual three-dimensional information model of the building. Digital twins are technologies from the areas of product development, manufacturing, supply chains, etc., and are focused on product life cycle management. In Croatia, some designers already use BIM tools, but BIM as a technology is not yet legally prescribed. Digital twins are a technology that, according to information from the field, is still not used in Croatia.

Act on Energy Efficiency [16] among other things, regulates smart buildings, i.e. advanced measurement systems in buildings. In Croatia, the current situation is such that policies and measures for the promotion of smart technologies and well-connected buildings and communities are defined almost exclusively at the local level through smart city development strategies, so there is (currently) no strategy at the national level.

The requirements for the inclusion of electromobility are integrated into *the Construction Act* in articles 21.a, 21.b and 21.c [18], in such a way that for new buildings and buildings undergoing significant renovation, non-residential purposes, with more than ten parking spaces, at least one charging point and channel infrastructure for at least one of every five parking spaces, and for more than twenty parking spaces, at least one charging point must be installed. For new buildings and buildings undergoing significant renovation, residential purposes, with more than ten parking spaces, channel infrastructure is installed for each parking space to enable the installation of charging points for electric vehicles at a later stage.

In the area of the circular economy in the building sector in Croatia, there is *a Program for the Development of Circular Management of Space and Buildings for the period 2021-2030* [41] for encouraging measures of circularity in the planning of new buildings and defining construction guidelines according to the principles of the circular economy, encouraging the reuse of buildings and spaces and extending the durability of existing spaces and buildings, encouraging measures to reduce the amount of construction waste and increase energy efficiency and the use of renewable energy sources, and reuse of existing construction products and materials. The set priorities of this program are the revitalization of unused spaces and buildings and

guidelines for planning the renovation of existing and construction of new buildings according to the principle of the circular economy model, and the measures are aimed at increasing the durability and lifetime of buildings in the area, increasing the energy efficiency of buildings, and reducing the generation of construction waste in order to stimulate sustainable development.

In the area of green public procurement, Croatia had adopted *the National Action Plan for Green Public Procurement for the period 2015-2017 with a projection to 2020* [42], and at the session of the Government of the Republic of Croatia held in May 2021, *the Decision on Green Public Procurement in Central Public Procurement Procedures* was adopted *(Official Gazette 49/2021)* [43]. With this Decision, the Government sent a strong political message about its commitment to climate policy and circular economy policy. The goal in 2030 is to have 75% of public procurement procedures implemented with green public procurement criteria applied. In addition, the ministry responsible for environmental protection is responsible for regularly updating and publishing green public procurement standards in Croatian on the national website for green public procurement https://www.zelenanabava.hr/ .

The integration of renewable energy sources and efficient heating and cooling technologies by encouraging the introduction of heat pumps is elaborated through several measures in the *National Energy Efficiency Action Plan for the period 2022-2024* [15]. The measure Decarbonization of the heating system in the public sector finances and encourages the electrification of the heating system using heat pumps with the mandatory production of electricity from photovoltaic systems on the building itself, as well as the connection of buildings to the existing efficient centralized heating systems and the development of new central heating systems to supply a larger number of building. T*he Energy Efficiency Program for the Decarbonization of the Energy Sector* finances and encourages the replacement of natural gas boilers with water/water heat pumps. The measure Increasing the efficiency of the heating system also encourages the introduction of heat pumps.

4. Key data on building and energy sectors

The construction sector, especially the building sector, represents an important part of the national economy of the Republic of Croatia. Despite the various crises in the last 10 years (war in Ukraine, pandemic, outflow of qualified workers abroad, etc.), this sector achieves a constant growth when viewed through the multi-year average. The growth accelerated after Croatia's entry into the European Union, so the sector experienced significant development in a qualitative sense. Migrant workers represent a significant share of the total number of workers in the construction sector in Croatia. In the last few years, there has been an increase in the number of migrant workers who come not only from neighbouring countries, but even from Asia. They often perform the simplest physical work on the construction sites and are often employed due to the lack of local workers in certain segments of the construction industry. It is important to mention that the construction sector is also changing significantly due to the influence of new technologies such as the application of information technologies such as BIM (Building Information Modeling) and other digital tools for project management, which enables better cooperation and efficiency in the building construction process. Sustainable building technologies are also becoming increasingly important, with an emphasis on energy efficiency, waste management and renewable energy sources.

4.1 National building stock by types and properties

Long-term Strategy for National Building Stock Renovation by 2050 [14] states that the national fund of existing buildings of the Republic of Croatia in 2020 includes a total usable area of 237,315,397 m², of which 178,592,460 m² are residential buildings and 58,722,937 m² are non-residential buildings.

Table 4 National fund of existing buildings in Croatia in 2020 (source: [14])

Type of buildings	Floor area, m²
Residential buildings	178.592.460
Non-residential buildings	58.722.937
TOTAL	237.315.397

The total pool of buildings also includes buildings with the status of immovable cultural heritage and buildings owned and used by the armed forces. Buildings with the status of immovable cultural heritage are included *in the Register of Cultural Property of the Republic of Croatia* (https://registar.kulturnadobra.hr), according to which 102,615 buildings within cultural and historical units have the status of cultural property, or 1,950 buildings have the status of individually protected cultural heritage.

The historical overview of building construction until 2018 is shown in Table 5.

Table 5 Historical overview of constructed buildings in Croatia (source: [14])

Year	Number of residential buildings	Floor area, m²	Number of non-residential buildings	Floor area, m²	Total number of buildings	Total floor area, m²
until 1941	101.592	15.929.536	14.703	3.043.972	**116.295**	**18.973.508**
1941 - 1970	237.466	37.236.847	35.112	10.880.447	**272.578**	**48.117.294**
1971 - 1980	152.991	26.564.857	25.754	7.133.934	**178.745**	**33.698.791**
1981 - 1987	112.782	23.860.990	14.481	7.260.279	**127.263**	**31.121.269**
1988 - 2005	113.973	24.317.951	21.655	10.829.784	**135.628**	**35.147.735**
2006 – 2009	32.018	10.840.732	9.872	8.425.747	**41.890**	**19.266.479**
2010 - 2011	11.576	3.423.022	3.347	2.768.198	**14.923**	**6.191.220**
2012 - 2018	16.011	4.750.743	17.746	7.151.193	**33.757**	**11.901.936**
TOTAL	**778.409**	**146.924.678**	**142.670**	**57.493.554**	**921.079**	**204.418.232**

Figure 1 shows a graph of the dynamics of building construction in the period from 1941 to 2018, using the same data as shown in Table 5, but the data is summarized so that each period in the graph covers approximately the same length of time due to a more realistic comparison, i.e. the display of dynamics (built-up area buildings are summarized by the periods 1941–1970, 1971–1987, 1988–2005 and 2006–2018).

The graph shows that the peak of building construction was in the 1970s and 1980s, but also that in the period from the end of World War II to the end of the 1960s, 2.5 times more buildings were built than had existed in the Republic of Croatia until then (48.12 million m² compared to 18.97 million m²). The trend of construction fell significantly after the independence of the country, but in the period 2006-2018 sees some recovery in that area.

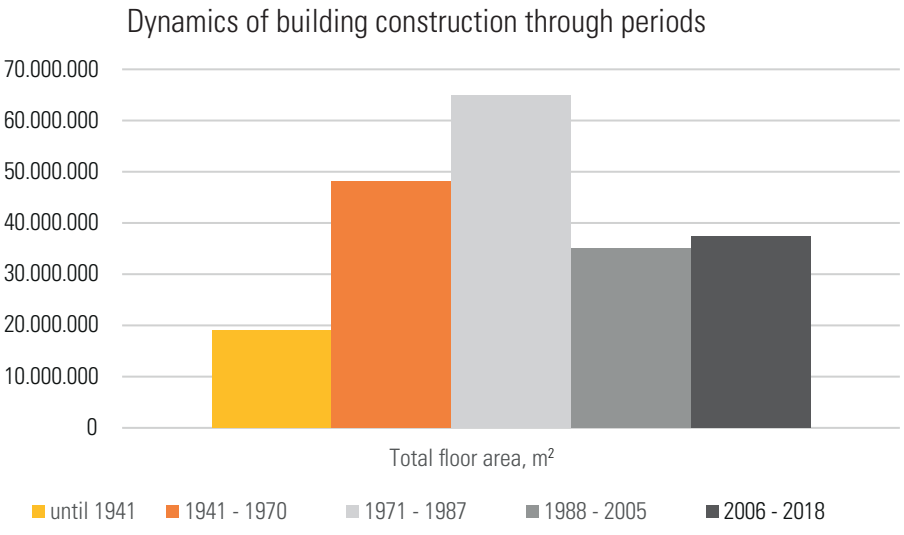

Figure 1 Dynamics of building construction through periods

The National Building Fund of the Republic of Croatia is classified according to purpose into the following categories:

- apartment buildings,
- family houses,
- public purpose buildings,
- commercial buildings.

For the classification of buildings, the definitions of building types given in the national programs of energy renovation of family houses, multi-apartment buildings, public sector buildings and commercial non-residential buildings were used.

- Public sector buildings are buildings predominantly owned by the public sector in which social activities (education, science, culture, sports, health and social welfare), activities of the state government and state administration, as well as local and regional bodies and organizations are carried out, self-government, activities of legal entities with public powers, then buildings for housing communities, including barracks, penitentiaries, prisons, correctional centers and other buildings for the armed forces, police or firefighters, buildings of citizens' associations and buildings of religious communities.
- A family house is a building in which more than 50% of the gross floor area is intended for housing and meets one of the two conditions listed: it has a maximum of three residential units and/or has a gross construction area less than or equal to 600 m^2.
- A multi-apartment building is any building that is entirely or in which more than 50% of the gross floor area is intended for housing and has three or more residential units and is managed by a building manager, who is a legal or natural person, in accordance with the Law on Property and other real rights.
- Commercial buildings are all buildings in majority ownership in which more than 50% of the gross floor area is intended for business and/or service activities.
- Buildings with the status of cultural heritage are found in all four categories of buildings.

The document *Energy in Croatia in 2021* states the total fund includes 76.92% residential buildings and 23.08% non-residential buildings, and the building stock increased compared to the previous year by a total of 2,881,707 m^2 of usable area, of which 1,551,977 m^2 were residential buildings and 1,329,730 m^2 of non-residential buildings [11].

4.2 Annual rate of new constructions and renovations

4.2.1 Current situation in the field of new constructions and reconstructions in Croatia

In Croatia, the value of works carried out with own workers in 2022 compared to 2021 increased significantly, so the value of works carried out on buildings with own workers in 2022 totalled slightly more than EUR 1.6 billion (Table 6). This is the result of increased demand from the private sector with the main drivers being the subsidization of housing loans for young people, the growth of employment and living standards and wages, as well as the citizens and entrepreneurs savings.

The data in this table includes new construction, reconstructions, repairs and maintenance of existing buildings, both residential and non-residential. It should be emphasized here that the table contains data for the value of completed works of business entities with 20 or more employees, but also entities with 5 or more employees. The data are not identical, but are presented in the same table for comparison.

Table 6 Value of construction works on buildings done in Croatia (source: [44])

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Value of construction works on buildings done with own workers (entities w. 20 or more employees), mill. euro	678	694	772	814	918	1.047	1.135	1.164	1.293	1.612
Increase compared to the previous year		2%	11%	5%	13%	14%	8%	3%	11%	25%
Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Value of construction works on residential buildings (legal entities w. 5 or more employees), mill. euro	253	253	300	300	358	444	499	586	699	na
Value of construction works on non-residential buildings (legal entities w. 5 or more employees), mill. euro	578	613	661	711	782	837	917	957	1.035	na
Value of works on buildings total, mill. euro	**831**	**866**	**961**	**1.011**	**1.140**	**1.281**	**1.416**	**1.543**	**1.734**	na
Increase compared to the previous year		4%	11%	5%	13%	12%	11%	9%	12%	na

The value of realized construction works is not the best indicator of the growth of the construction sector because it does not necessarily mean an increase in the physical volume of works. That's why trends in construction and reconstruction of buildings should be monitored through the number of building permits issued and the area realized as a result of these works, which is shown in Table 7, Table 8 and Table 9.

Table 7 Number of issued building permits for new constructions, additions and reconstructions of residential and non-residential buildings (source: [44])

Year	Number of issued BM, new constructions and reconstructions	Total floor area, m^2	- of which residential buildings, m^2	- of which non-residential buildings, m^2
2013	5.430	1.730.362	999.924	730.438
2014	5.587	1.933.672	963.714	969.958
2015	5.132	2.487.012	884.866	1.602.146
2016	6.414	2.635.237	1.179.985	1.455.252
2017	7.779	2.948.552	1.581.013	1.367.539
2018	7.798	2.660.114	1.563.065	1.097.049
2019	8.194	3.065.121	1.923.207	1.141.914
2020	7.800	2.864.442	1.772.174	1.092.268
2021	8.991	3.450.808	2.121.078	1.329.730
2022	9.715	4.145.460	2.462.986	1.682.474

Based on these data, we can see a real increase in new constructions and reconstructions, which were in decline only in the first year of the pandemic (2020). In order to have an even better picture, Table 8 separately shows the number of building permits issued for building reconstructions.

Table 8 Number of issued building permits for reconstructions only, total (source: [44])

Year	Number of issued BM for reconstructions, total	- of which residential buildings	- of which non-residential buildings
2013	NA	NA	NA
2014	NA	NA	NA
2015	1.751	1.231	520
2016	2.130	1.535	595
2017	2.392	1.724	668
2018	2.250	1.621	629
2019	2.177	1.614	563
2020	1.961	1.496	465
2021	2.079	1.511	568
2022	1.876	1.346	530

Finally, Table 9 shows the actual state of building construction by year, based on which we can see the number of completed residential and non-residential buildings and the built-up area of buildings. It is worth noting here that buildings completed in 2019 and later are not necessarily nZEB buildings, because permits for those buildings could have been requested before the obligation to build according to the nZEB standard, and the shortest deadline for completing construction according to [18] is 5 years from registration of the start of construction.

Table 9 Number of newly completed buildings (source: [44])

Year	Number of completed buildings total	- of which residential buildings	- of which non-residential buildings	Completed buildings total, floor area, 000 m²	- of which residential buildings, 000 m²	- of which non-residential buildings, 000 m²
2013	5.739	4.566	1.173	1.943	1.256	687
2014	4.971	3.841	1.130	1.658	1.019	639
2015	4.641	3.678	963	1.898	979	919
2016	4.824	3.811	1.013	1.832	1.012	820
2017	4.940	3.699	1.241	2.029	1.041	988
2018	4.933	3.824	1.109	2.207	1.302	905
2019	5.521	4.316	1.205	2.567	1.430	1.137
2020	5.745	4.580	1.165	2.465	1.524	941
2021	6.071	5.007	1.064	2.461	1.632	829

4.2.2 Long-term plan for energy renovations of buildings and new constructions in Croatia

According to [14] the projection of building growth until 2050 shows a growth of 6% in the stock of residential buildings, and a growth of 14% in the stock of non-residential buildings (Table 10). It should be taken into account that this is a projection that took into account the expected decrease in the population of the Republic of Croatia to 3.3 million inhabitants in 2050. The number of inhabitants in the Republic of Croatia in 2021 was 3,871,833 [44].

Table 10 Expected growth of new buildings in the period from 2020 to 2050 (source: [14])

Type of buildings	Floor area 2030, m²	Floor area 2050, m²	Increase
Residential buildings	178.592.460	189.646.889	6%
Non-residential buildings	58.722.937	66.732.712	14%
TOTAL	**237.315.397**	**256.379.601**	**8%**

One of the strategic goals *of the Long-Term Strategy* is to raise the building renovation rate from the current 0.7% per year to 3% by 2030. The planned rates of energy renovation of the existing fund according to the Long-Term Strategy are for the period from 2014 to 2020 0.7% of the area, i.e. 1.35 million m² per year, then 1% in 2021 and 2022, 1.5% in 2023 and in 2024, 2.0% in 2025 and 2026, 2.5% in 2027 and 2028 and 3% in 2029 and 2030, then from 2031 to 2040 3.5% and 4% from 2041 to 2050.

Table 11 shows the target areas and the renewal rate from 2021 to 2030.

Table 11 Target floor areas and building energy renovation rate from 2021 to 2030 (source: [14])

	2021	2022	2023	2024	2025
Target rate of energy renovation	1,0%	1,0%	1,5%	1,5%	2,0%
Renovated residential buildings, m²	1.101.440	1.090.425	1.619.282	1.594.992	2.094.757
Renovated non-residential buildings, m²	587.229	579.869	860.002	846.014	1.109.669
Total renovated buildings, m²	1.687.918	1.670.294	2.479.284	2.441.006	3.204.426
	2026	**2027**	**2028**	**2029**	**2030**
Target rate of energy renovation	2,0%	2,5%	2,5%	3,0%	3,0%
Renovated residential buildings, m²	2.052.861	2.514.755	2.451.886	2.868.707	2.782.646
Renovated non-residential buildings, m²	1.086.075	1.328.727	1.293.836	1.511.831	1.464.578
Total renovated buildings, m²	3.138.936	3.843.482	3.745.722	4.380.538	4.247.224

The total area of renovated residential buildings in 2030 will be 20,171,751 m² (65 %), non-residential buildings 10,667,830 m² (35 %), which together gives a total area of 30,839,581 m² of renovated buildings. Figure 2 graphically shows the rates of energy renovation of buildings by two-year periods until 2050. The upcoming period 2021-2030 it is specially highlighted in the picture in the chart.

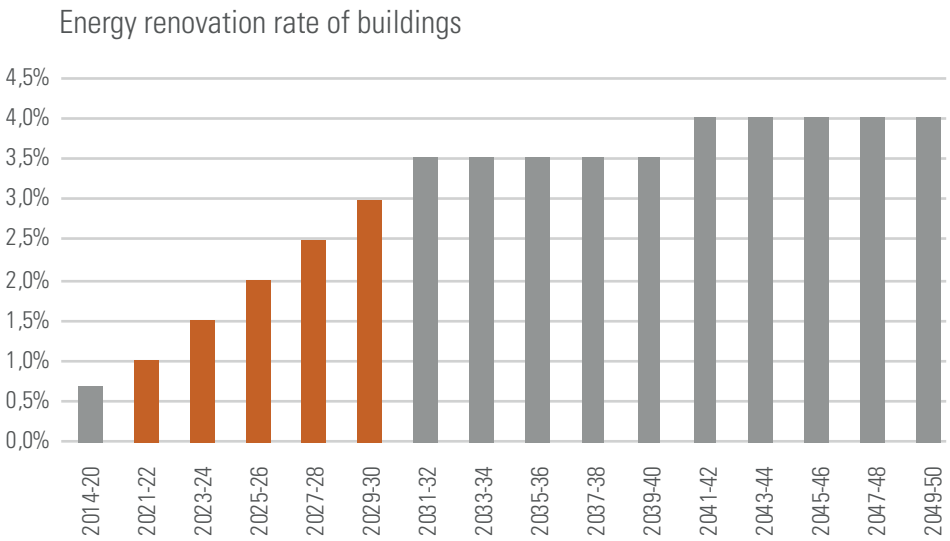

Figure 2 Energy renovation rate of buildings

In the following decades, the goals for the area of renovated buildings are thus 30.84 million m² of renovated buildings by 2030, 41.06 million m² from 2030 to 2040 and 32.10 million m² from 2040 to 2050.

Table 12 shows this data in a bit more detail, with the addition of a presentation of the expected new construction of buildings in certain decades.

Table 12 Targets of energy renovation of buildings and new construction by decades (source: [14])

	2021-2030	2031-2040	2041-2050
Renovation of residential buildings, mill. m²	20,17	26,97	21,12
Renovation of non-residential buildings, mill. m²	10,67	14,10	10,98
Total renovation of buildings, mill. m²	**30,84**	**41,07**	**32,10**
Replacement of demolished stock - residential, mill. m²	2,40	2,16	2,54
New construction - residential, mill. m²	9,60	9,60	10,16
New construction - non-residential, mill. m²	3,27	2,49	1,69
Total demol./new construction, mill. m²	**15,27**	**14,25**	**14,39**
TOTAL RENOVATION AND NEW CONSTRUCTION, mill. m²	**46,11**	**55,32**	**46,49**

Figure 3 shows these goals for the energy renovation of residential and non-residential buildings individually and in summary. It is clearly visible that the contribution of residential renovation of buildings is twice as large as compared to non-residential renovation.

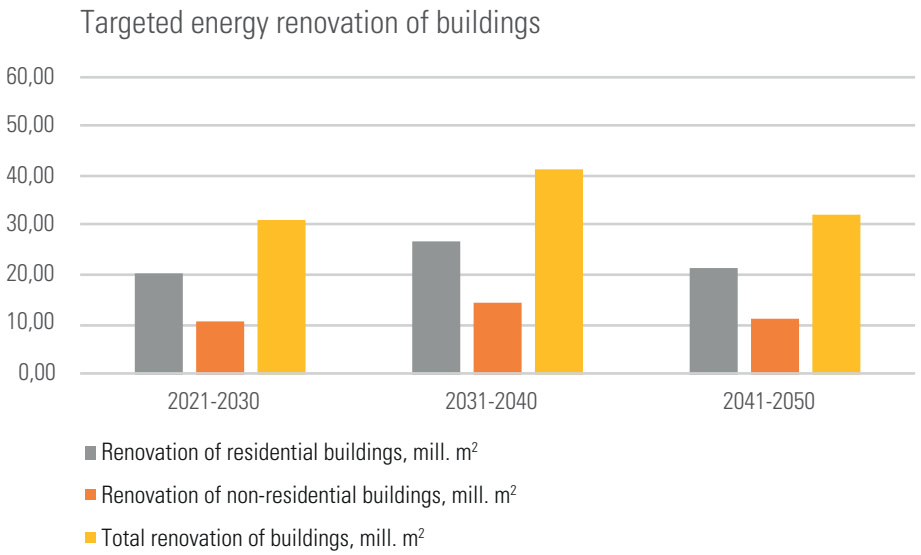

Figure 3 Targeted energy renovation of buildings until 2050 by decades

Figure 4 shows the specific targets for total building renovation and new construction, individually and in summary. It is clearly visible that the contribution of the renovation of buildings is twice as large compared to the new construction of buildings.

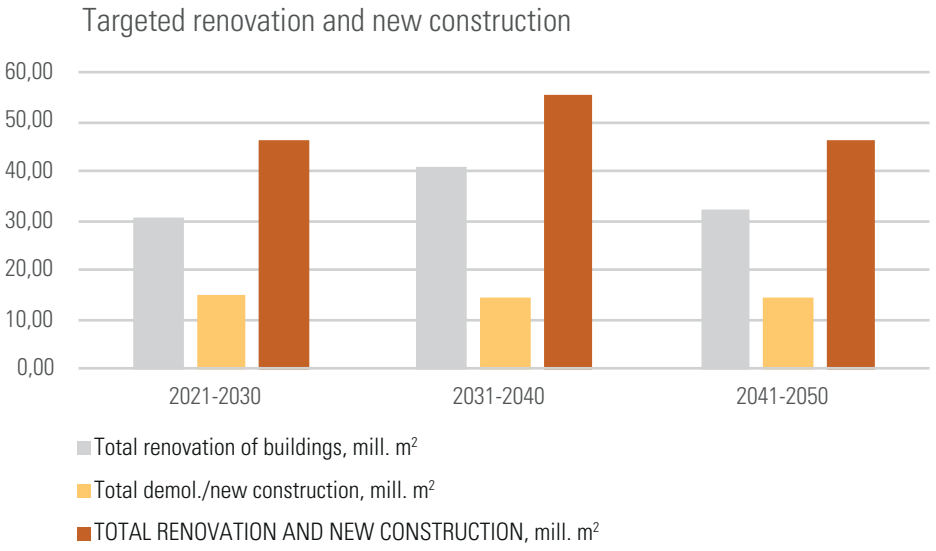

Figure 4 Targeted renovation and new construction of buildings until 2050 by decades

The share of renovated buildings in 2050 depends on the approach to building renovation and the total size of the building stock - unrenovated, renovated and new. The expected decrease in the number of inhabitants in the country, even with the expected increase in the spatial standard from the current 30 m²/person to 48 m²/person in 2050, shows that in 2050, 158 million m² of living space will be permanently inhabited in the Republic of Croatia [14].

As for the expected savings achieved during the energy renovation, the buildings with the worst energy properties have the greatest potential. Table 13 shows the types of buildings by purpose according to the ratio of supplied and required energy, which shows how much supplied energy is actually lost by certain types of buildings. The average ratio of supplied and required energy is 1.27 kWh/kWh. According to the ratio of the total delivered and required energy for heating and cooling, sports halls, hospitals and store buildings are the worst. These are the consumers with the lowest efficiency, but at the same time they have the greatest potential for achieving savings, and energy-renovated ones can make a big contribution to energy goals.

Table 13 Buildings according to the ratio of delivered and required energy (source: [14])

Purpose of the building	Ratio of total delivered and required energy for heating and cooling
Sports halls	1,58
Hospitals	1,54
Shops/malls and retail store buildings	1,51
Multi-apartment buildings	1,36
Other non-residential buildings heated to a temperature of +18 or higher	1,21
Hotels and restaurants	1,19
Office buildings	1,14
Family houses	1,12
Buildings for education	1,05
AVERAGE	**1,27**

For the conclusion, it is important to note that the current production capacity of the construction sector in high-rise construction according to statistical data is approximately 3.0 million m² per year (2,948 in 2017), and the maximum was reached in 2007 (5.5 million m²) [14]). Considering the decline in the number of inhabitants, it is assumed that such a maximum size of the sector will be difficult to reach and that the ultimate reach will be approximately 5 million m² per year in 2050, assuming linear growth.

4.2.3 Estimation of necessary investments for renovation, new construction and nZEB

The total investment cost of the energy renovation of buildings was calculated with the current values of the assumed renovation prices up to the nZEB standard. For residential buildings, the price is 330 EUR/m², while for non-residential buildings it is 460 EUR/m², due to the existence of more complex technical systems in such buildings. Table 14 shows the investment cost for renovation and for new construction. For the replacement of the demolished and new construction, a direct estimate from the Long-Term Strategy was taken out [14].

Table 14 Estimated investments for the renovation and new construction of buildings (Source: [14])

	2021-2030	2031-2040	2041-2050
Renovation of residential buildings bill. EUR	6,66	8,90	6,97
Renovation of non-residential buildings bill. EUR	4,91	6,49	5,05
Total renovation of buildings bill. EUR	**11,56**	**15,39**	**12,02**
Total demol. and new construction of buildings bill. EUR	15,71	14,43	14,28
Total renovation and new construction of buildings bill. EUR	**27,28**	**29,82**	**26,31**

According to the *Energy Development Strategy of Croatia - Green Book* [45], the construction of new buildings will also significantly affect the achievement of the goals, which, based on the legal obligation, must meet the nZEB standard from 2020 onwards. Given that this is a regulatory measure, it is not necessary to foresee financial incentives but regardless of that, Table 15 contains an estimate of the necessary investments, which will mostly come from the private sector.

Table 15 Investments in nZEB buildings by scenarios from the Energy Development Strategy of Croatia (source: [45])

Scenario	S1			S2		
Period	2021-2030	2031-2040	2041-2050	2021-2030	2031-2040	2041-2050
Scope of nZEB new construction, mil. m²	13,77	15,01	16,24	10,93	14,72	15,11
Investment cost of nZEB new construction, bill. EUR	48,20	52,54	56,84	38,26	51,53	52,89
Investment cost of the scenario, bill. EUR	157,58			142,68		

The general national goal of increasing energy efficiency by 2030 is determined by Article 3 of *the Act on Energy Efficiency* [16]. With these legal provisions, Croatia assumed the obligation defined in Article 3 *of Directive (EU) 2018/2002 of the European Parliament and of the Council of December 11, 2018, amending Directive 2012/27/EU on energy efficiency* [24].

Article 8 of *the Act on Energy Efficiency* [16] determines the need to define measures to ensure the annual renewal of 3% of the total floor area of heated and/or

cooled buildings that are owned and used by the central government, in order to meet at least the minimum energy requirements, i.e. the minimum energy efficiency requirements for buildings, or building units in accordance with the technical regulation governing the area of rational energy use and thermal protection in buildings.

4.2.4 Energy renovation program goals until 2030

Energy Renovation Program of Multi-apartment Buildings for the period until 2030 [17]: A total of 6.3 million m^2 should be renovated in the period until 2030. On an annual level, this would mean the renovation of an average of about 700,000 m^2, in the period from 2022 to 2030, which would achieve the goals of the *Long-term Strategy for National Building Stock Renovation by 2050*. Estimated investments for the renovation of multi-apartment buildings according to the objectives of the *Long-term Strategy for National Building Stock Renovation* amounts to EUR 2.3 billion in the considered ten-year period. In order to achieve the goals in the segment of multi-apartment buildings, it is necessary to provide approximately EUR 1.56 billion in grants from public sources by 2030, and the primary source is the funds from the National Recovery and Resilience Plan (grant funds) and from ESI funds (financial instrument).

Energy renovation program for family houses: The program had not yet been adopted at the time this document was created. There are certain estimates that the estimated investment cost in the period 2021-2030 amounted to EUR 3.16 billion.

Energy Renovation Program of Public Sector Buildings [19]: The program refers to the segment of public sector buildings, which represent 27.4% of the total non-residential stock, i.e. 9.5% of the total stock of buildings in the Republic of Croatia. In total, over 2.9 million m^2 should be renovated in the period until 2030. On an annual level, this would mean the renovation of an average of about 325,000 m^2 in the period from 2022 to 2030, which would achieve the goals of the *Long-term Strategy for National Building Stock Renovation by 2050*. The assumed cost of energy renovation is 330 EUR/m^2 . Estimated investment cost in the period 2021-2030 is 1.16 billion EUR.

Energy renovation program of buildings that have the status of cultural heritage [20]: The Ministry of Culture and Media received data on the estimated number of buildings located within cultural-historical entities that have the status of cultural heritage. There is information on the number of such buildings and their location (city, conservation department or county). By processing these data with regard to the buildings included in the scope of this program, it is estimated that there are 102,615 buildings within cultural and historical units in Croatia, of which 44,889 are in continental Croatia and 57,726 are in coastal Croatia. Within this number there are also 1,950 individual buildings that have the status of cultural property. For buildings within cultural-historical units that do not have the status of individual cultural property, there is no information on classification according to purpose and period of construction. By analyzing data from EMIS and applying it to the total national fund of public buildings taken from *the Long-term strategy for encouraging investment in the renovation of the national building fund,* an estimate was obtained that the national fund of public buildings that are the subject of this program amounts to 2,302,158 m^2. Also, it was estimated that in the Republic of Croatia, the national fund of multi-apartment buildings that are the subject of this Program is 9,247,069 m^2 , while the fund of family houses that are the subject of this Program is 14,468,001 m^2. Following from all of the above, it is estimated that the total national fund of buildings that are the subject of this program is 26,017,228 m^2 . The total needs for the implementation of the program of energy renovation of buildings that have the status of cultural property, and with the purpose of achieving national goals, are described in more detail in the program and amount to EUR 1.52 billion in the period from 2022 to 2030. The stated amount includes the necessary investments and maintenance costs. Total renovated area: 2,471,333 m^2 . The basic

goal of the program is an average renovation rate of 1.1% of the total area of buildings that have the status of cultural property on an annual basis in the period until 2030. The planned annual renewal rate in 2022 is 0.8% and gradually increases until 2030, when it is 1.6%.

Program for Suppression of Energy Poverty Implementation 2021-2025 [46]. This Program analyzed the buildings owned and managed by *the Central State Office for Reconstruction and Housing* in which residents are not able to participate in the financing of necessary repairs, and especially in energy renovation. The program analyzed 413 buildings (5,382 residential units) where urgent and non-postponable major construction interventions are primarily related to renovations or reconstructions of roofing, sheet metal works, carpentry and facades. These are smaller residential buildings that generally have 5 to 20 apartments. Most of them were built in the end of the 1960s and the beginning of the 1970s and, generally, they were not maintained and no serious construction work was ever done on them. Out of 5,382 housing units, 2,069 or 38.44% are currently owned by the Republic of Croatia. The program also envisages the use of renewable energy sources, mainly photovoltaic systems, the total potential of which can ensure the production of electricity at the location for self-consumption in the amount of about 4,360 MWh per year. The cost of energy renovation is estimated at EUR 47 million.

4.3 Number of low energy buildings (nZEBs)

According to the data collected by the Ministry of Physical Planning, Construction and State Assets from the administrative departments that perform spatial planning and construction tasks, a total of 145 nZEB buildings were built in the period from April 1, 2014 to December 31, 2019, with a total area of 176,981 m². In the database of building energy certificates (for certificates entered until October 29, 2019), there are a total of 616 buildings that meet the conditions, but since there was no obligation to fulfil the requirements for nZEB in the production of energy certificates, therefore this information was not entered. Accordingly, 1.6% of buildings for which energy certificates were issued in 2018 and 2019 are nearly zero energy buildings. The data above is contained in Table 16.

Table 16 Number of registered nZEB buildings by the end of 2019 (source: [14])

Year	Number of nZEB buildings	Floor area, m²	Gross area, m²
2017	40	51.050	62.010
2018	55	67.992	82.938
2019	50	28.801	32.033
TOTAL	**145**	**147.843**	**176.981**

We requested data from the Ministry of Physical Planning, Construction and State Assets on the number and areas of nZEB buildings for the period from 2020 onwards. The Ministry explained that from January 1, 2020 all constructed buildings must be nZEB (except for those for which, due to the physics and purpose of the building, compliance with the nZEB standard is not foreseen) and gave its opinion that from the usage permits issued from January 1, 2020 could conclude exactly the number of nZEB buildings involved, but there is no central system in which all usage permits issued since January 1, 2020 are recorded. The Ministry provided additional information that until the end of 2019, local (and regional) self-government units submitted data on nZEB buildings to the Ministry, but it is considered that after that all buildings were nZEB, so the Ministry stopped collecting data on this. In the future, it will be easier to track all the relevant information because work is underway to upgrade the ISPU (*Physical Planning Information System*) system, in which the data on the issued location, construction and usage permits would be available.

Through direct written communication with the Ministry, we still managed to obtain preliminary data on completed nZEB buildings after 1 January 2020 with a note that the precise data is still not available, since that it is difficult to filter whether it is a new building or an apartment in a new building, or just a business space within a building, etc., and that the data are only approximate considering the data entered in the system of energy certificates. Table 17 shows that number of buildings and their areas. This is a completely different way of data tracking and we cannot compare it with the way shown in Table 16. Therefore, we cannot aggregate these data.

Table 17 Approximate number of nZEB buildings after January 1, 2020 according to Ministry of Physical Planning, Construction and State Assets

Year	Number of nZEB buildings	Floor area, m^2	Gross area, m^2
2019	172	163.701	192.547
2020	473	235.989	300.265
2021	1.048	639.295	708.274
2022	2.190	1.084.526	1.532.197
1 Jan-30 June 2023	1.149	570.392	715.499
TOTAL	**5.032**	**2.693.904**	**3.448.781**

By looking at the number of building permits issued for the period from 1 January 2020 [44] we can further see the trend of increasing the number of nZEB buildings in the future. In doing so, it should be taken into account that a certain number of issued building permits in the databases of the Croatian Bureau of Statistics were not issued for nZEB buildings, that is why we filtered the data so that Table 18 shows data for buildings that must definitely be built according to the nZEB standard (*note: KOB buildings means Buildings for cultural and artistic activities and entertainment, education, hospitals and other buildings for health purposes, and ZSZ Buildings means Buildings for community housing*). Unfortunately, from data from, for example, 2020, we cannot draw a conclusion as to how many buildings that received construction permits in that year were actually built and when.

Table 18 Planned nZEB buildings - number of issued building permits after January 1, 2020 (source: [44])

Type of buildings	Floor area, m^2					Number of issued building permits (new constructions)				
	2020	2021	2022	Jan-Apr 2023	TOTAL	2020	2021	2022	Jan-Apr 2023	TOTAL
New buildings	**2.053.139**	**2.460.203**	**3.034.927**	**1.084.170**	**8.632.439**	**5.123**	**6.081**	**7.074**	**2.636**	**20.914**
Residential	1.642.896	1.984.811	2.345.829	852.048	6.825.584	4.782	5.665	6.691	2.466	19.604
1 apartment	628.436	755.879	892.483	352.098	2.628.896	3.141	3.698	4.376	1.694	12.909
2 apartments	134.892	171.000	195.600	65.856	567.348	518	637	697	223	2.075
3 or more	873.752	1.050.624	1.218.538	398.534	3.541.448	1.116	1.324	1.609	539	4.588
Buildings CEH	5.816	7.308	39.208	35.560	87.892	7	6	9	10	32
Non-resident.	410.243	475.392	689.098	232.122	1.806.855	341	416	383	170	1.310
Hotels etc.	149.289	110.301	161.797	82.915	504.302	99	107	130	63	399
Offices	47.893	70.425	80.126	15.300	213.744	60	65	40	17	182
Shops/malls	115.406	136.492	285.040	53.541	590.479	98	127	126	40	391
Buildings CH	97.655	158.174	162.135	80.366	498.330	84	117	87	50	338

According to another source from the Ministry of Physical Planning, Construction and State Assets, and based on the processing of data from the database of energy certificates on July 7, 2023. (e-mail communication), the number of buildings listed in the certificate database as the nZEB new buildings is a total of 4,932, of which 4,071 are residential, and 861 are non-residential. The number of the buildings reconstructed to the nZEB level is a total of 960, of which 714 are residential and 246 non-residential.

4.4. Breakdown of the building stock by energy label

The energy properties of buildings are determined according to the data from energy certificates entered into the database of *the Information System of Energy Certificates* until May 25, 2023. *The Information System of Energy Certificates* can be found at https://eenergetskicertifikat.mgipu.hr [34], but in addition to searching that database, we also directly requested data from the Ministry of Physical Planning, Construction and State Assets.

According to these data, the total number of certificates is 133,930 (Table 19). The data analysis revealed that the highest percentage in the number of energy certificates belongs to family houses, which makes up 48.54% of the total number of certificates, followed by apartment buildings with a share of 39.10%. Sports halls and hospitals account for the smallest percentage of energy certificates, with a share of only 0.27% for sports halls and 0.29% for hospitals.

Table 19 Distribution of buildings by energy classes based on heat energy required for heating ($Q_{H,nd}$)

BUILDING TYPE	ENERGY CLASS BASED ON SPECIFIC ANNUAL HEAT ENERGY REQUIRED FOR HEATING								
	G	F	E	D	C	B	A	A+	Suma
Family houses	8081	7149	9593	10597	13892	9580	4730	1394	65016
Multi-apartment buildings	867	1291	3024	7795	16845	14457	6042	2046	52367
Trade services buildings	188	282	425	649	923	699	260	128	3554
Educational buildings	22	42	99	197	415	460	173	52	1460
Office buildings	66	95	295	691	1458	1342	443	183	4573
Sports halls	14	22	33	49	90	95	39	21	363
Hotels and restaurants	129	115	171	275	603	396	283	96	2068
Other non-residental buildings	321	399	561	669	1006	831	257	98	4142
Hospitals	43	28	37	61	92	96	28	2	387

According to the distribution of energy classes by energy required for heating (Figure 5) it is evident that as much as 12% of the total number of certificates for family houses belongs to class G, which also applies to 11% of certificates for hospitals. On the other hand, the lowest percentage of G class energy certificates, only 1%, refers to office buildings. When it comes to energy certificates of class A+ according to the required energy for heating ($Q_{H,nd}$), the largest number of such certificates belong to multi-residential buildings. According to the individual type of building, the highest percentage of A+ class energy certificates belong to sports halls.

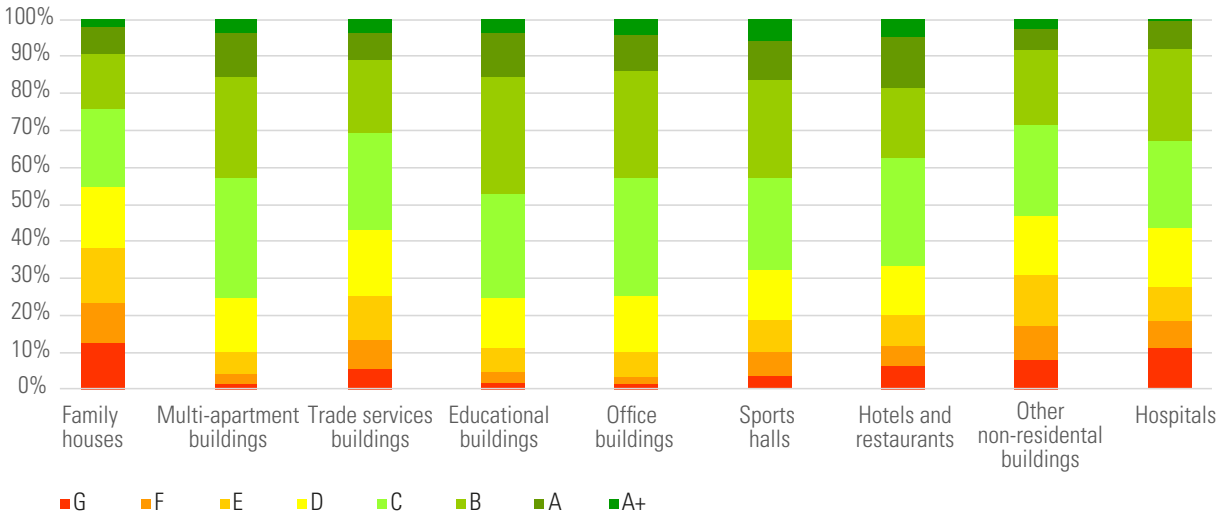

Figure 5 Distribution of energy classes by energy required for heating (QH,nd)

An overview of the energy classes of buildings by primary energy (E_{prim}) shows a greater number of energy certificates with a better class according to total primary energy. In the case of hotel and restaurant buildings and office buildings, there is a significant difference in energy class according to the required thermal energy for heating and the rating according to primary energy, which is less favourable due to the number of lower energy classes. The main reason for this is that primary energy includes energy for cooling and lighting, which makes up a significant proportion of these types of buildings.

According to the distribution of buildings by energy classes based on primary energy (Table 20) the most buildings with energy class A+ belong to apartment buildings (7,492 certificates) and family houses (5,369 certificates). Office buildings show the worst energy class G with 1,270 certificates. These data emphasize the need to improve energy efficiency in office buildings and preserve the high standard of energy class A+ in family houses and apartment buildings.

Table 20 Distribution of buildings by energy classes based on primary energy (E_{prim})

BUILDING TYPE	ENERGY CLASS BASED ON SPECIFIC ANNUAL PRIMARY ENERGY								
	G	F	E	D	C	B	A	A+	Suma
Family houses	714	1242	3375	14219	26763	6887	6447	5369	65016
Multi-apartment buildings	402	467	1224	6342	22721	6807	6912	7492	52367
Trade services buildings	89	130	269	175	138	787	959	1007	3554
Educational buildings	147	87	117	217	390	86	61	355	1460
Office buildings	1270	452	487	514	655	483	429	283	4573
Sports halls	5	9	13	21	32	42	59	182	363
Hotels and restaurants	686	111	181	192	210	126	221	341	2068
Other non-residental buildings	152	136	266	747	1119	480	539	703	4142
Hospitals	34	26	40	27	30	25	18	187	387

According to the distribution of energy classes based on primary energy (Figure 6), it can be seen that as many as 33% of hotel and restaurant certificates belong to class G, which is also true for 28% of office buildings. On the other hand, the lowest percentage of G class energy certificates, only 1%, refers to family houses, apartment buildings and sports halls. When it comes to energy certificates of class A+ according

to the distribution of energy classes based on primary energy, the largest number of such certificates belongs to family houses and apartment buildings. According to the individual type of building, the highest percentage of A+ class energy certificates belong to sports halls.

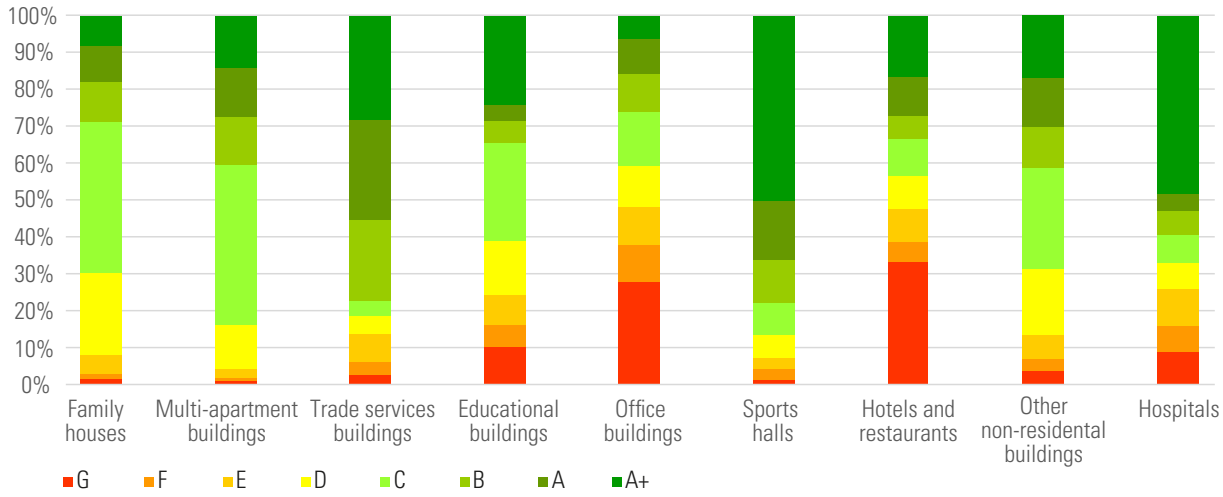

Figure 6 Distribution of energy classes by primary energy (Eprim)

Based on this analysis of energy certificates, it was determined that the largest number of certificates belongs to family houses and apartment buildings. Family houses and multi-apartment buildings also have a high proportion of A+ class certificates both based on the specific annual required thermal energy for heating and on the basis of the specific annual primary energy. Additionally, the analysis of the distribution of energy classes based on primary energy reveals that office buildings and hotel/restaurant buildings often show lower energy classes.

4.5 Number of companies, crafts and trades operating in the building sector

By searching the statistical data of the State Bureau of Statistics (https://podaci.dzs.hr) we found the total number of legal entities, trades and free professions in the Republic of Croatia. In 2022, a total of 19,469 legal entities were active in the Construction sector, and there were 10,570 trades and freelancers. Table 21 contains data going back to 2013.

Table 21 Number of legal entities, crafts and trades and free lances in the construction sector in Croatia, 0-500 employed and more (source: [44])

Year	Number of legal entities, registered - Construction	Number of legal entities, active - Construction	Number of crafts and trades and free lances - Construction
2013	23.138	16.492	8.868
2014	23.683	17.037	8.356
2015	25.246	18.610	bp
2016	22.589	12.707	7.679
2017	24.027	13.439	7.546
2018	22.239	13.635	7.607
2019	24.236	15.161	8.011
2020	26.499	15.756	8.700
2021	30.840	18.065	9.832
2022	33.638	19.469	10.570

Regarding the number of employed persons, we managed to obtain data that we can say reflect the situation in the building sector itself (Table 22). According to these data, a significant majority of persons out of a total of 110,937 persons employed in the construction sector are employed in the building sector (which, in addition to construction of buildings and specialized construction activities, also includes employees in civil engineering).

Table 22 Number of employees in legal entities in buildings (source: [44])

Year	Number of employees in legal entities, Construction of buildings	Number of employees in legal entities, Specialised construction activities	Number of employees in legal entities, Construction sector (total)	Number of employees in all legal entities
2013	27.755	21.863	73.832	1.132.246
2014	26.751	22.224	72.028	1.120.507
2015	26.437	21.969	71.751	1.175.656
2016	29.176	25.794	78.031	1.229.726
2017	31.024	27.619	81.604	1.265.021
2018	33.807	30.358	86.727	1.305.439
2019	37.473	34.407	93.761	1.341.433
2020	39.974	37.332	100.093	1.336.081
2021	41.909	40.337	105.904	1.362.169
2022	44.107	43.687	110.937	1.402.240

It should be clarified here that employees in specialized construction activities include not only employees exclusively in the construction profession, but also employees in other compatible professions (mechanical engineering, electrical engineering, finishing and other construction works). A detailed description can be found on the link [47].

Table 23 shows the number of employees in the trades and professions, but we could not filter the data only for the building sector, so the data is presented for the entire construction sector.

Table 23 Number of employees in crafts and trades and free lances, Construction sector (source: [44])

Year	Employees in crafts and trades and free lances, Construction sector	Employees in crafts and trades and free lances, total
2013	20.584	206.658
2014	19.765	198.911
2015	19.802	194.142
2016	19.970	193.524
2017	20.342	192.233
2018	20.863	192.665
2019	21.505	194.348
2020	22.137	188.602
2021	23.445	194.861
2022	23.965	199.072

The last table, Table 24, shows employees in architectural activities and engineering.

Table 24 Number of employees in architectural and engineering activities; technical testing and analysis (source: [44])

Year	2017	2018	2019	2020	2021	2022
Architectural and engineering activities; technical testing and analysis	23.298	24.091	25.348	24.996	26.276	27.320

The data includes an estimate of the number of employees in legal entities that have less than ten employees, for which no reports have been received.

4.6 Structure and statistics on the current professionals in the building sector

By inspecting the databases *of the Croatian Bureau of Statistics* and data processing, as well as coordination with the project partners, we came to the number of employees in legal entities according to their level of education according to the European Qualification Framework (EQF). Table 25 shows the above data. The data does not include an estimate of the number of employees in legal entities that have less than ten employees, and for which reports have not been received, therefore a direct comparison with the number of employees from the previous chapter is not possible. Data for the past three years are shown; before that, the data was not kept according to EQF and therefore we did not process it.

Table 25 Employed persons in legal entities by EQF level of education (source: [44])

Year	Activity	EQF 8	EQF 7	EQF 6	EQF 5	EQF 4	EQF 3	EQF 2	EQF 1
2020	**Construction of buildings**	2	2.422	1.181	566	11.493	7.946	3.042	3.500
2020	**Specialised construction activities**	12	1.871	993	625	15.095	6.094	1.042	1.677
2020	**Architectural and engineering activities**	105	10.555	2.234	478	6.332	528	164	160
	TOTAL	119	14.848	4.408	1.669	32.920	14.568	4.248	5.337
2021	**Construction of buildings**	3	2.587	1.184	492	12.851	9.026	2.847	3.661
2021	**Specialised construction activities**	5	2.168	1.048	562	17.308	6.466	947	1.542
2021	**Architectural and engineering activities**	146	11.214	2.462	584	6.624	437	105	165
	TOTAL	154	15.969	4.694	1.638	36.783	15.929	3.899	5.368
2022	**Construction of buildings**	16	2.805	1.273	379	13.751	8.863	2.891	3.699
2022	**Specialised construction activities**	3	2.300	1.083	361	18.784	6.645	1.246	1.915
2022	**Architectural and engineering activities**	145	12.036	2.384	451	7.004	515	92	159
	TOTAL	164	17.141	4.740	1.191	39.539	16.023	4.229	5.773

The project partners have jointly mapped the EQF levels to the existing vocational education categories and accordingly how they are defined in the database [44]:

- EQF8 – number of employees listed in the database under the category: Graduate and postgraduate studies (doctors)
- EQF7 – number of employees listed in the database under the category: Graduate and postgraduate studies (masters)

- EQF6 – number of employees listed in the database under the category: Undergraduate studies
- EQF5 – number of employees listed in the database under the category: Short professional study
- EQF4 – number of employees listed in the database under the category: Gymnasium
- EQF4 – number of employees listed in the database under the category: Vocational secondary school lasting 4 to 5 years
- EQF3 – number of employees listed in the database under the category: Secondary vocational school for a duration of 1 to 3 years
- EQF2 – number of employees listed in the database under the category: PKV
- EQF1 – number of employees listed in the database under the category: Elementary school.

The largest share of workers has an education level according to EQF 4 (so-called "blue collars"), followed by workers with EQF level 7 (so-called "white collars"), and then workers with EQF level 3 (also "blue collars"). Figure 7 shows all other shares.

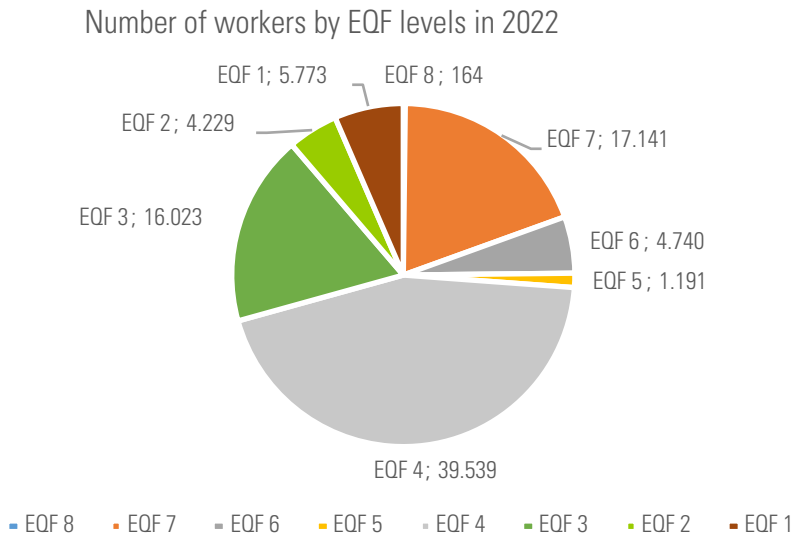

Figure 7 Number of workers by EQF levels in 2022

We also performed a detailed analysis of the number of members of the chambers of civil engineers, architects, electrical engineers and mechanical engineers. We took the data from the available directories and records of the chambers themselves at the following Internet addresses:

- Croatian Chamber of Civil Engineers - https://www.hkig.hr/
- Croatian Chamber of Architects - https://www.arhitekti-hka.hr/
- Croatian Chamber of Electrical Engineers - https://www.hkie.hr/
- Croatian Chamber of Mechanical Engineers - https://www.hkis.hr/.

According to data from these databases in Croatia as of June 30, 2023 members of all chambers hold a total of 17,042 different authorizations. Of that number, 4,805 are authorized in the Chamber of Civil Engineering, 2,714 in the Chamber of Architects, 2,056 in the Chamber of Electrical Engineers and 1,282 in the Chamber of Mechanical Engineers. Since some of the members have more than one authorization, we counted such members only once and analyzed them according to the level of education as their titles are entered in the databases (e.g. B.Sc., M.Sc., Ph.D., M.Sc. sc., professional spec., etc.). The project partners also mapped this data together according to EQF levels, so that Table 26 shows the final result of the analysis and mapping.

Table 26 Number of members of all chambers of architects and engineers by EQF level of education

Profession and types of license according to the chambers' directories	EQF 8	EQF 7	EQF 6	EQF 5	TOTAL
Licensed construction designers and supervising engineers, construction site engineers, work managers and auditors	243	5.144	1.540	9	6.936
Licensed architects, construction site engineers and work managers	63	2.549	109	7	2.728
Licensed electrical engineers, construction site engineers, work managers, electrical technicians and independent offices' owners	110	1.913	389	20	2.432
Licensed mechanical engineers, construction site engineers, mechanical technicians and independent offices' owners	54	1.389	164	56	1.663
TOTAL	**470**	**10.995**	**2.202**	**92**	**13.759**

4.7 Energy consumption and renewable energy in buildings

4.7.1 Energy consumption and energy production from RES in buildings

According to the document *Energy in Croatia,* the total energy consumption in buildings in 2021 is 47.2% of the total direct (final) energy consumption in Croatia (total consumption of buildings, industry, transport, construction and agriculture) [11]. Table 27 shows direct energy consumption in Croatia and energy consumption in buildings and especially in households (consumption in buildings was not available for the period from 2016 to 2018, no data). There was a noticeable drop in consumption in buildings in the first year of the pandemic, which was immediately followed by a recovery in consumption. By comparing the total energy consumption in households and electricity in households, we can immediately see that thermal energy represents about 75% of energy consumption in households.

Table 27 Final energy consumption in Croatia with consumption in buildings and households from 2016 (2019) to 2021 (source: [11])

Year	2016	2017	2018	2019	2020	2021
Direct energy consumption in Croatia (GWh)	77.039	80.431	79.525	80.239	75.025	80.983
Energy consumption in all buildings (GWh)	no data	no data	no data	39.534	36.687	38.224
Energy consumption in households (GWh)	28.011	27.819	26.731	26.031	26.478	28.403
Electricity consumption in households (GWh)	6.128	6.266	6.202	6.206	6.077	6.594

Below is an overview of capacity and energy production from RES in the building sector. From all available statistical data on RES capacities and energy production from RES in all sectors, we have extracted data that are primarily valid for the building sector.

Firewood represents a significant source of thermal energy for heating buildings in Croatia. In 2021, 13,058 GWh of renewable energy was produced from this energy source and other biomass (Table 28).

Table 28 Generated renewable energy from firewood and biomass for buildings from 2016 to 2021 (source: [11])

Year	2016	2017	2018	2019	2020	2021
Generated energy from firewood and biomass for buildings (GWh)	**13.194**	**12.783**	**12.214**	**11.867**	**12.033**	**13.058**

Incomparably less energy was produced from RES for the needs of buildings from geothermal systems and heat pumps, as shown in Table 29.

Table 29 Generated renewable energy from geothermal systems and heat pumps for buildings from 2018 to 2021 (source: [11])

Year	2018	2019	2020	2021
Installed thermal power in geothermal systems for heating buildings (MW)	45,60	45,10	46,50	59,60
Production of primary energy from heat pumps (GWh)	174,72	167,78	170,00	194,44
Production of thermal energy from geothermal energy - only heating of buildings (GWh)	88,94	83,56	49,86	57,72
Production of thermal energy from geothermal energy - heating of buildings and DHW (GWh)	113,50	104,78	64,56	74,89

** DHW = domestic hot water*

In 2021, there was even slightly more energy produced from solar thermal systems than from heat pumps, a total of 198.50 GWh, as shown in Table 30.

Table 30 Generated renewable energy from solar thermal systems for buildings from 2018 to 2021 (source: [11])

Year	2018	2019	2020	2021
Installed thermal power in solar thermal systems (MW)	45,60	45,10	46,50	59,60
Production of thermal energy from solar thermal systems (GWh)	174,72	167,78	170,00	194,44

Table 31 contains data on the current growth of capacity and production of photovoltaic power plants only for the building sector from 2014 to 2022. Figure 8 shows the data based on that table, and it is easy to see the almost exponential increase in the capacity of installed photovoltaic power plants in buildings.

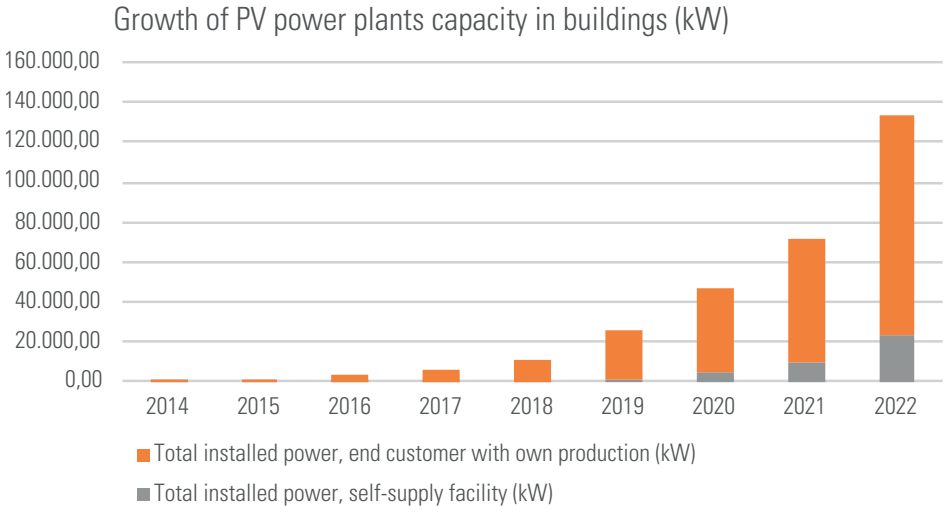

Figure 8 Growth of PV power plants capacity in buildings (kW)

Table 31 shows data on capacity growth and total electricity production from photovoltaic power plants, especially for users of self-supply facilities (e.g. owners of family houses) and especially for end customers with their own production (e.g. entrepreneurs).

Table 31 Growth of RES capacity and production of photovoltaic power plants in buildings from 2014 to 2022 (source: [12], HEP Opskrba)

Year	Total installed power, self-supply facility (kW)	Total installed power, end customer with own production (kW)	Total installed power in buildings (kW)	Total production of PV power plants in buildings (GWh)
2014	37,00	514,22	551,22	0,63
2015	64,12	1.660,22	1.724,34	1,98
2016	165,83	3.727,08	3.892,91	4,48
2017	322,78	6.134,39	6.457,17	7,43
2018	449,42	11.144,32	11.593,74	13,33
2019	887,00	24.747,64	25.634,64	29,48
2020	5.108,80	41.980,95	47.089,75	54,15
2021	9.367,65	62.562,62	71.930,27	82,72
2022	22.769,73	110.604,01	133.373,74	153,38

The increase in the total production of photovoltaic power plants dynamically follows the increase in their capacity (Figure 9).

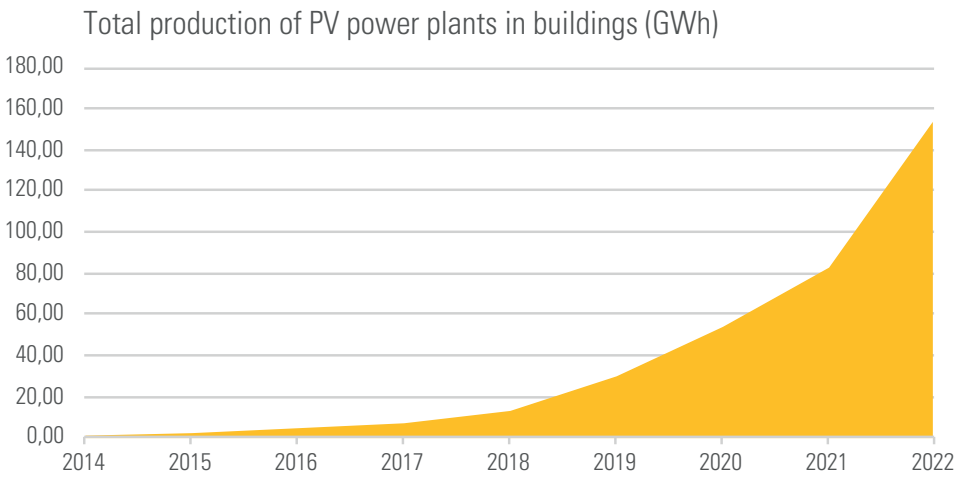

Figure 9 Total production of PV power plants in buildings (GWh)

4.7.2 Expected production of energy from RES in buildings until 2030

By analyzing, processing and interpreting the data in the Integrated National Energy and Climate Plan for the Republic of Croatia for the period 2021-2030, we created an overview of the expected dynamics of capacity growth and energy production from RES in buildings until 2030.

Table 32 shows the future contributions of technologies in the production of energy from RES, which we can claim are valid almost exclusively for the field of buildings. Biomass, thermal energy from the Sun, geothermal systems, i.e. shallow heat pumps, overhead pumps and photovoltaic power plants are covered. The penultimate column contains the estimated contribution of all photovoltaic power plants, both those for self-supply and those of producers who produce electricity exclusively for the market.

Table 32 Expected energy production capacity in buildings from renewable sources in the period 2022-2030 (source: [8])

OIE technology	Biomass boilers and furnaces for heating	Solar thermal systems for heating	Geothermal systems (heat pumps) for heating and cooling	Above-ground heat pumps for heating and cooling	Production and integrated photovoltaic power plants	Integrated photovoltaic power plants (only buildings)
Year	Solid biomass (GWh/y.)	Solar energy, thermal (GWh/y.)	Geothermal energy (GWh/y.)	Thermal RES (GWh/y.)	PV power plants, incl. producers (GWh/y.)	Integrated PV power plants (GWh/y.)
2022	13.036	259	174	648	309	153
2023	13.115	277	208	707	398	199
2024	13.193	293	241	766	486	243
2025	13.272	311	273	826	573	287
2026	13.351	327	306	885	662	331
2027	13.429	343	340	944	749	374
2028	13.508	361	372	1.004	837	419
2029	13.587	377	405	1.063	926	463
2030	13.665	393	437	1.122	1.013	506

In order to get a picture of the expected production of photovoltaic power plants in the building sector, as initial data we took the data on the production of electricity in the building sector from 2022 (Table 31). Since the expected increase in energy production from other technologies grows linearly, we applied the same dynamics to this initial data and obtained an estimate of the growth of energy production from photovoltaic power plants in buildings until 2030.

Table 33 contains data on the expected increase in the capacity of RES systems in buildings, and for the calculation of the estimate of the increase in the capacity of photovoltaic power plants in buildings, we proceeded in the same way.

Table 33 Expected installed power of RES systems in buildings in the period 2022-2030 (source: [8])

OIE technology	Biomass boilers and furnaces for heating	Solar thermal systems for heating	Geothermal systems (heat pumps) for heating and cooling	Above-ground heat pumps for heating and cooling	Production and integrated photovoltaic power plants	Integrated photovoltaic power plants (only buildings)
Year	Solid biomass (MW)	Solar energy, thermal (MW)	Geothermal energy (MW)	Thermal RES (MW)	PV power plants, incl. producers (MW)	Integrated PV power plants (MW)
2022	7.242	209	35	130	269	133
2023	7.286	223	42	141	346	173
2024	7.329	236	48	153	423	211
2025	7.373	250	55	165	499	249
2026	7.417	264	61	177	575	288
2027	7.461	277	68	189	651	326
2028	7.505	291	74	201	728	364
2029	7.549	304	81	213	805	402
2030	7.592	317	87	224	881	440

According to the data in this chapter, we come to the calculation that the production of energy from RES in buildings in 2022 is a total of 14,270 GWh, and the expected production in 2030 will be a total of 16,123 GWh. If we compare the data stated above with the data that in 2021 the total energy consumption in all buildings in Croatia amounted to 38,224 GWh, it is very evident how important the production of energy from RES is for the building sector.

5. Existing provisions in the field of Education and Training

5.1. Vocational level education

The education system in the Republic of Croatia consists of: preschool education, basic education, secondary education and higher education. Depending on the type of curriculum they implement, secondary schools, are called:

1. **Gymnasiums** (general or specialized) in which the curriculum is carried out for at least four years.

2. **Vocational schools** lasting from one to generally four years, exceptionally five, upon completion of which the student acquires a qualification of a certain level, volume, profile and quality, which is proven by a public document, the content and form of which is prescribed by the minister responsible for education.

3**. Art schools** (music, dance, art and others, which is determined by the type of curriculum) in which the curriculum is carried out for at least four years.

The existing system of vocational education covers 70.9% of the total secondary school population, i.e., 135,930 students in 290 schools.

According to educational programs the system of regular **vocational education** for the acquisition of lower and secondary professional qualifications consists of:

• **one-year and two-year lower professional qualifications** in 23 educational programs. The number of students attending these programs is 1,000, which is 0.7% of the total number of vocational education students, or 0.5% of the total high school population.

• **three-year programs** for occupations in industry and craftsmanship in 93 educational programs. They are attended by 49,560 students, which is 36.5% of the total number of vocational education students, or 25.9% of the total high school population.

• **four-year technical and similar programs** in 83 educational programs. They are attended by 85,370 students, which is 62.8% of the total number of vocational education students, or 44.5% of the total high school population.

The Ministry of Science and Education is responsible for the regulation of preschool education, primary and secondary education in the country and abroad. It adopts the national curriculum, approves textbooks, norms and standards and other conditions for educational work, school development, student standards, inspection supervision. The Ministry makes decisions on the establishment and supervises the legality of the work of institutions and ensures financial and material conditions for work in upbringing and education; training of children, young people and adults for the acquisition of technical knowledge and skills and the activities of associations in this area.

Within the Ministry, the Directorate for Education operates within 2 sectors: the Sector for Early, Preschool and Primary School Education and the Sector for Secondary Education and Adult Education, which has the Service for Vocational Education and the Service for the Secondary School System of Education and Adult Education. The responsibility of these services is the promotion and improvement of vocational and adult education: monitoring and supervision of the achievement of goals and components of national curriculum documents and school curricula, participation in the development of curricula related to high school education. It performstasks related to professional training and development and licensing of educational workers.

The administration participates in the monitoring, improvement and development of the work of the Agency responsible for vocational education and adult education. Vocational education is the most represented form of education and is attended by 70% of the secondary school population.

On the Agency's website: https://www.asoo.hr/obrazovanje/strukovno-obrazovanje/pretrazivanje-obrazovanja/ is possible to obtain information about all schools, programs and the number of students in which secondary vocational education is carried out.

The programs are classified by sector (Construction and Geodesy, Electrical Engineering, Mechanical Engineering, etc.). Vocational education can be conducted through several models: classic, Single model of education (JMO), Dual model (DO). They differ from each other in terms of the number of hours of practical classes and their content, as well as the conditions that must be met by the school in order to be approved for work license (e.g., the number of licensed student placements, the equipment of the school's practicums, and similar).

Regular Vocational high school education is the responsibility of state schools, which are financed with the funds of the Ministry of Science and Education and the funds of the Counties, that is, the City of Zagreb, as founders of high schools. Each county has an Administrative Department for Education that has some of the following responsibilities:

- registers students in secondary schools through the prescribed information application,
- approves the proposal to enroll students in secondary school
- determines the appropriate form of education for students with developmental disabilities,
- determines minimum technical and hygienic conditions for premises where adult education programs are carried out

Regardless of the adopted National Pedagogical Standard [1] of the secondary school education system, there are great differences in the equipment of schools and school workshops and the conditions of schooling of students in them. Most secondary vocational schools educate students in several educational sectors, especially in smaller towns. The specificity is the large number of smaller schools with more programs and the approval of classes with a smaller number of students, especially in deficit occupations.

Since there is no single database for monitoring students attending VET education and those who have completed VET education, as part of the CROskill RELOAD project, the deep analysis of the number and structure of students in the Construction and Geodesy sector was accomplished by conducting a survey. The analysis was carried out by the members (principals and teachers) of the Association of Construction Schools, which has 30 members of high schools that educate students in the Construction and Geodesy sector. The principals have collected data from all schools in their counties, Table 34.

Table 34 List of schools where the analysis was carried out

County	Schools where construction professions are covered	Schools where mechanical engineering professions are covered
Krapinsko – zagorska	Srednja škola Bedekovčina	Srednja škola Krapina Srednja škola Konjščina
Sisačko – moslavačka	Strukovna škola Sisak	Industrijsko-obrtnička škola Sisak Srednja škola Glina Tehnička škola Kutina Tehnička škola Sisak
Karlovačka	Mješovita industrijsko-obrtnička škola, Karlovac	Tehnička škola Karlovac Obrtnička i tehnička škola Ogulin
Varaždinska	Graditeljska, prirodoslovna i rudarska škola	Elektrostrojarska škola Varaždin
Koprivničko-križevačka	Obrtnička škola Koprivnica Srednja škola „Ivan Seljanec“ Križevci	Strukovna škola Đurđevac
Bjelovarsko-bilogorska	Tehnička škola Bjelovar Obrtnička škola Bjelovar	Tehnička škola Daruvar
Primorsko-goranska	Građevinska tehnička škola Graditeljska škola za industriju i obrt	Drvodjeljska i strojarska škola Rijeka Strojarska škola za industrijska i obrtnička zanimanja, Rijeka Srednja škola za elektrotehniku i računalstvo Srednja škola Pavla Rittera Vitezovića Senj
Ličko-senjska	-	Srednja škola Pavla Rittera Vitezovića u Senju
Virovitičko-podravska	-	Industrijsko-obrtnička škola Virovitica Industrijsko-obrtnička škola Slatina Tehnička škola Virovitica
Požeško-slavonska	Srednja škola Pakrac Obrtnička škola Požega	Tehnička škola Požega
Brodsko-posavska	Srednja škola Matije Antuna Reljkovića Tehnička škola Obrtničko-tehnička škola	Industrijsko-obrtnička škola Slavonski Brod
Zadarska	Srednja škola kneza Branimira Benkovac Tehnička škola	Srednja škola kneza Branimira Benkovac Strukovna škola Vice Vlatkovića
Osječko-baranjska	Srednja strukovna škola Antuna Horvata Đakovo Graditeljsko-geodetska škola Osijek	Prva srednja škola Beli Manastir Elektrotehnička i prometna škola Osijek Srednja škola Valpovo
Šibensko-kninska	Tehnička škola Šibenik	Industrijsko-obrtnička škola Šibenik Srednja škola Ivana Meštrovića Drniš Srednja strukovna škola kralja Zvonimira Knin
Vukovarsko-srijemska	Tehnička škola Ruđera Boškovića Vinkovci	Tehnička škola Nikole Tesle, Vukovar Obrtničko-industrijska škola Županja Tehnička škola Županja
Splitsko-dalmatinska	Graditeljsko-geodetska tehnička škola Škola za dizajn, grafiku i održivu gradnju Klesarska škola	Obrtničko- industrijska škola u Imotskom Tehnička i industrijska škola Ruđera Boškovića u Sinju Srednja strukovna škola Blaž Jurjev Trogiranin, Trogir Obrtna tehnička škola Split Industrijska škola, Split Srednja strukovna škola Makarska Elektrotehnička škola Split Obrtnička škola Split
Istarska	Industrijsko-obrtnička škola Pula Tehnička škola Pula	Srednja škola Mate Blažine Labin
Dubrovačko-neretvanska	Obrtnička i tehnička škola Dubrovnik Srednja škola Metković	Pomorsko-tehnička škola Dubrovnik Srednja škola Petra Šegedina Korčula
Međimurska	Graditeljska škola Čakovec	Tehnička škola Čakovec
Grad Zagreb i Zagrebačka	Obrtnička, industrijska građevinska škola Zagreb Graditeljska tehnička škola Zagreb	Srednja škola Dugo Selo Srednja škola Jastrebarsko Srednja strukovna škola Velika Gorica Srednja strukovna škola Samobor Srednja škola Vrbovec Industrijska strojarska škola Škola za montažu instalacija i metalnih konstrukcija Srednja škola Dragutina Stražimira Sveti Ivan Zelina Srednja škola Ivan Švear Ivanić Grad

In the Construction and Geodesy sector, there are only 5 schools that have only construction professions: *Graditeljska tehnička* škola in Zagreb, *Graditeljska* škola Čakovec*, Građevinska tehnička* škola in Rijeka*, Graditeljsko-geodetska* škola *Osijek* and *Graditeljsko-geodetska tehnička* škola in Split. Other schools have more sectors and a smaller number of students in construction professions. The tradition of educating students in construction is quite present in central Croatia in Hrvatsko Zagorje and Zagreb. Based on Table 35, in the 2018/19 school year, there were a total of 4,040 students in 34 institutions and 267 classes. Of that number, 815 students were in three-year occupations. In the 2021/22 school year, there were a total of 3,749 students in 33 institutions and 278 classes. Of that number, 1,056 students were in three-year occupations.

The statistics show a decrease in the number of students in the sector. The average number of students in a classroom is 17.

The analysis covers 30 secondary schools that educate students in construction trades from 18 counties. There is no school in the Lika-Senj County that has a construction sector. Occupations include knowledge and skills that would be applicable in energy-sustainable construction.

The following four-year occupations were analyzed: architectural technician, construction technician, sustainable development and construction technician and stonemason technician.

The following three-year occupations were analyzed: mason, carpenter, facade worker, stonemason, roofer, insulator, rebar worker, dry construction fitter, flooring installer, tile setter.

The analysis covers 48 secondary schools that educate students in the field of mechanical engineering and electrical engineering from 17 counties.

The following occupations were analyzed: electrical technician (four-year) and three-year: heating and air conditioning installer, installer, fitter, electrical fitter, electrical fitter, gas fitter.

The analysis covers 48 secondary schools that educate students in the field of mechanical engineering and electrical engineering from 17 counties.

The following occupations were analyzed: electrical technician (four-year) and three-year: heating and air conditioning installer, installation fitter, wireman, electrician, gas fitter. The school years 2018/19, 2019/20, 2020/21, 2021/22 were analyzed, Table 35.

Table 35 Number of students in professions for 4-years period

		School year	2018./19.				2019./20.	
	Level qualifications	JOB	Entry quota for occupation	Number of students who completed the profession	The total number of students from 1 to 3rd/4th gr.	Total number of students (girls) in each profession for the school year. (from 1st to 3rd or 4th grade) - if you do not have information, put 0	Entry quota for occupation	Number of students who completed the profession
Construction sector	Four-year occupations	Architectural technician	366	366	1408	623	388	258
		Construction technician	217	220	784	178	236	284
		Technician of sustainable development and construction	0	0	0	0	0	0
	Three-year occupations	Stone mason technician	22	17	49	6	22	7
		Mason	77	26	107	0	61	39
		Stone mason	30	2	11	0	22	7
		Facade worker	18	7	14	0	19	12
		Carpenter	6	0	8	0	16	6
		Roofer	6	0	0	0	6	0
		Insulator	0	0	0	0	0	0
		Rebar worker	6	0	0	0	0	0
		Dry construction fitter	80	40	113	0	84	41
		Flooring installer	6	0	2	0	6	0
		Tile setter	103	61	134	6	122	72
sector of mechanical engineering, electrical engineering and computing	Four-year occupations	Electrical technician	345	337	1213	21	322	297
		Heating and air conditioning installer	291	199	600	0	286	230
		installation fitter	14	13	48	0	24	21
	Three-year occupations	Electrician	174	149	404	0	183	123
		Wireman	41	14	73	0	30	22
		Gas fitter	23	12	40	0	19	10

2019./20.		2020./21.				2021./22			
The total number of students from 1 to 3rd/4th gr.	Total number of students (girls) in each profession for the school year. (from 1st to 3rd or 4th grade) - if you do not have information, put 0	Entry quota for occupation	Number of students who completed the profession	The total number of students from 1 to 3rd/4th gr.	Total number of students (girls) in each profession for the school year. (from 1st to 3rd or 4th grade) - if you do not have information, put 0	Entry quota for occupation	Number of students who completed the profession	The total number of students from 1 to 3rd/4th gr.	Total number of students (girls) in each profession for the school year. (from 1st to 3rd or 4th grade) - if you do not have information, put 0
1427	667	393	352	1365	722	370	358	1351	721
756	149	232	188	722	180	227	217	793	199
0	0	0	0	0	0	0	0	0	0
35	5	20	16	35	4	18	8	27	4
107	0	86	28	104	0	91	26	107	0
19	0	20	3	17	1	18	9	24	2
18	0	18	10	15	0	12	11	18	0
16	0	12	5	20	0	25	12	25	0
2	0	6	0	5	0	6	3	8	0
0		0	0	0	0	0	0	0	0
0		6	0	0	0	6	0	0	0
147	0	52	57	166	0	71	59	148	0
2	0	6	2	2	0	6	0	4	0
225	12	108	86	249	15	110	103	258	0
1176	33	282	294	1113	27	262	269	1052	28
578	0	291	254	754	0	303	318	425	0
62	0	24	17	66	0	24	26	70	0
421	0	182	136	514	1	203	180	535	2
79	0	30	25	81	0	42	29	87	0
39	0	20	16	50	0	20	14	52	0

Information was requested for each school year and for each occupation on: enrollment quota, the number of students who graduated that year (completed their education), the total number of students in that occupation, and the number of girls. The enrollment quota was intended to provide information on the possibilities and intentions of the school to enroll in the requested program. From this data, it is evident that schools offer enrollment in four-year occupations in both sectors and the quotas are filled at the enrollment, which is evident from the number of students who graduate and the total number of students. For example, the construction technician program is a very attractive program for students and interest in it is not decreasing. In 2018/19, there were 784 students in the program in all 4 classes, 220 students graduated. In the school year 2021/2022 there were 793 students in all 4 classes, and 217 students graduated. This shows stability in enrollment quotas and students' interest in technical four-year occupations. The result is very similar in other technical four-year occupations in both sectors. The interest in the architectural technician is even greater, but in some counties they reduce enrollment quotas because they treat it as a surplus occupation (Karlovačka County). There are more female students in this profession than in other technical professions. A large percentage of students who graduate continue their education at the university or other higher education institutions, predominantly in the technical field.

The smallest number of students among the four-year professions is in the stonemasonry technician profession because this education is closely related to one school, which is the **Stonemasonry School on the island of Brač. Unfortunately, regardless of very good educational conditions and top professional teachers, the number of students decreases over the years.**

In three-year occupations, the situation is much less favorable. Only about 20% of vocational school students enroll in some of the three-year professions. One of the reasons is the difficulty of continuing education, unpopularity, the perception that these are difficult jobs with low earnings and similar.

In three-year occupations, schools show interest in enrolling students because these are all occupations that are in short supply and are in high demand on the market. This is evident from the enrollment quotas. The CES (*HZZ*) provides support for enrollment in these occupations by publishing a list of shortage occupations for which the CES recommends schools to increase enrollment quotas, as well as a list of surplus occupations, i.e., programs for which schools and their founders are asked to reduce enrollment quotas. Some founders (counties) are very actively involved in approving enrollment programs. **Enrollment support is also provided by some employers through active scholarship measures, media campaigns and various supports for students who enter into an apprenticeship contract with them** (example PPK Karlovac Meat Industry, construction company Radnik Križevci,..). In addition, the majority of cities and counties provide scholarships to students studying in deficit occupations, and some cover the entire cost of education (transportation, textbooks, accommodation in a student dormitory, work clothes). In the past years, the Croatian Chamber of Trades and Crafts and the Agency for Vocational Education and Training and Adult Education joined the promotion through various promotional campaigns (Worldskills Croatia competitions).

Despite all these efforts, the number of students in three-year professions is below the capabilities of the schools and the needs of the labor market. It is evident from the table that, for example, the number of students studying to become a mason in 2019/20 as 104, 2020/21 107. In the school year 2022/23 which was not processed in the analysis, the number of students increased to 150 students. Very good entries were made by the Crafts and Industrial Construction School from Zagreb (13 more students), the School for Design, Graphics and Sustainable Construction from Split (6 more students), the Construction, Natural History and Mining School from Varaždin (6 more students). This is perhaps a good sign of some new

tendencies of students and their parents who guide them in choosing a profession and enrolling.

The analysis showed that some professions have completely disappeared, such as rebar worker, insulator. In Croatia, only 8 roofer-insulator students study at the school in Zagreb. Optimistic information is also the number of carpentry students, which increased from 8 to 25 from 2018 to 2022. This is certainly the result of incentives through scholarships.

In the Electrical Engineering sector, the enrollment in the four-year Electrical Technician profession is very good and excellent students enroll in this profession. The interest is very high. Not all schools are included in the table (large technical schools from Zagreb are missing (Tesla Technical School, Elektrotehnička škola Zagreb...) The number of students in 2021/22 in the Electrical Technician profession was 3204 (75 girls), and in 2018/19 the number was 3623. This is a consequence of the decrease in the total number of students, and the tendency of students to enroll in gymnasiums (mostly excellent students are enrolled there). The number of institutions where electrical technicians are trained also decreased from 38 to 35 (demographic trends).

In the three-year mechanical and electrical engineering professions, the interest of students is greater. In the professions of wireman, electrician, gas fitter, installation fitter, heating and air conditioning installer, the total number of students in the school year 2022/2023 is 2758 students in 65 institutions. In the school year 2018/19 there were 2041 students, Figure 10. The number of students there is also significantly higher, increasing, but the needs on the labor market are still greater.

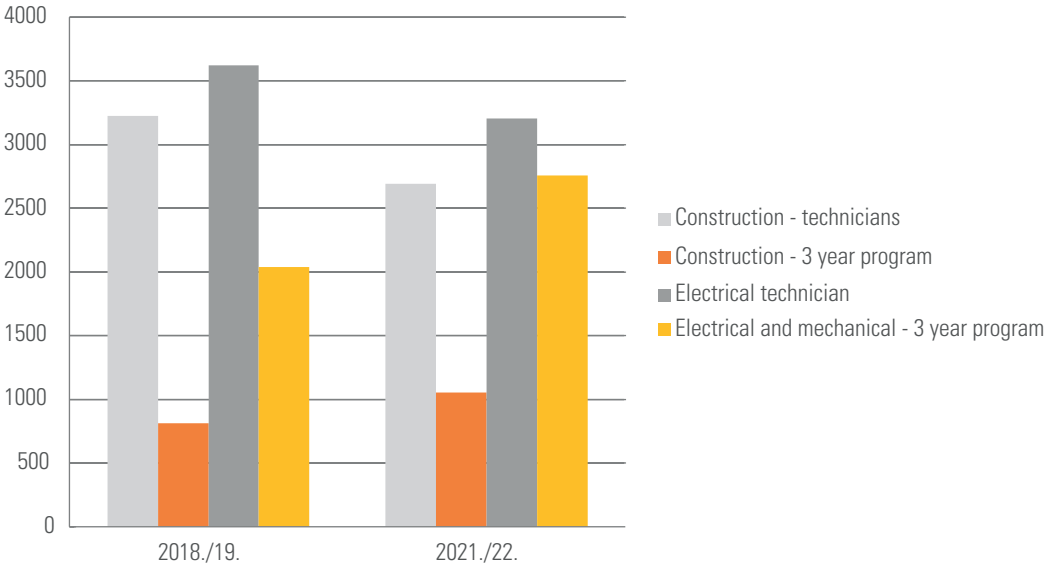

Figure 10 Number of students in the sectors Construction and Electrical Engineering and Mechanical Engineering (Total)

Courses related to Energy-efficient construction and renewable energy sources are insufficiently represented in the four-year occupations of architectural and construction technicians.

In the Architectural Structures subject program, the content of building physics and structural assemblies necessary to absorb solutions for passive architecture are taught. **The majority of schools do not have the spatial conditions to ensure a practical demonstration, nor are they equipped in collections of didactic material with examples of energy efficiency solutions**. As part of the Practicum course, students have the opportunity to visit construction sites where RES or EE construction solutions are applied. Also in schools, presentations are held by companies that

deal with the production or installation of RES or EE materials and technology. A good example of modernization of the program is the new Sustainable Development and Construction Technician program, which is in 2019/20 introduced by the Split School of Design, Graphics and Sustainable Construction. The program description consists of the content related to sustainable construction and environmental protection, sustainable business and the introduction of renewable energy sources into microgrids, optimization and monitoring of energy and water consumption, management of technical resources with the aim of energy efficiency, waste disposal and energy production, organization of recycling yards, management concerns about the impact of production on health and environmental protection.

It can be concluded that secondary school programs are outdated, do not sufficiently follow innovations and depend a lot on the interest and knowledge of teachers. In technical four-year occupations, students do not have enough practice (80 hours after 2nd and 3rd grade). **Learning based on practical knowledge is not sufficiently represented. The lack of professional literature is a big problem in all vocational programs.**

The Agency for Vocational Education and Training and Adult Education is in the process of developing qualification standards, occupational standards and curriculum, where the units on EnU and the application of RES will be reinforced in the teaching subjects. *The Strategy of Education, Science and Technology* (2014) [2] recognizes the importance of adopting the *National Curriculum for Vocational Education*, and based on it, the creation of a curriculum for the acquisition of qualifications in the regular system of vocational education is foreseen. Additionally, according to the *Strategic plan of the Ministry of Science and Education for the period 2020-2022* [3], the goal of improving the quality and relevance of vocational education is defined in such a way as to establish regional competence centers, modernize vocational curricula in order to harmonize education with the needs of the labor market, and strengthen the capacity and improvement of vocational teacher.

Respecting *the Science, Education and Technology Strategy*, the *Vocational Education and Training System Development Program 2016-2020* [4] was drawn up and adopted, which provided for the creation and adoption of the National Curriculum for Vocational Education and the methodology for creating sectoral curricula and curricula for the acquisition of individual qualifications.

The national curriculum for vocational education [5] was adopted in 2018, as was the *Law on Amendments to the Law on Vocational Education* (Official Gazette, 30/09, 24/10, 22/13, 25/18, 69/22) [6].

The sectoral curriculum is a framework that includes all vocational curricula that enable the acquisition of qualifications at levels 2 to 5 of the HKO of one educational sector and the associated sets of learning outcomes from the qualification standards.

The sectoral curriculum contains a list of all educational sector qualifications that can be acquired through vocational education within a particular educational sector, the duration of education, methods and conditions for achieving horizontal and vertical mobility within the educational sector, and models and recommendations for implementing all forms of work-based learning.

The introduction of new curricula with modular teaching and greater emphasis on work-based learning is planned to be introduced in the 2024/25 school year.

According to the *National Recovery and Resilience Plan 2021-2026* [20], the proportion of students in Croatia enrolled in gymnasium programs, with the intention of pursuing further education, stands at approximately 30%. This figure is comparatively low when compared to the EU member states' average of 52%. On the other hand, vocational education programs are attended by 70% of students, making Croatia one of the countries with the highest percentage of students engaged in upper secondary vocational education in Europe. A significant portion of these vocational

programs focuses on occupations in economics and trade, such as economists, commercialists, business secretaries, administrative officers, and hoteliers. However, it is worth noting that these occupations are currently experiencing a surplus in the labor market, where demand falls short of supply.

Addressing the surplus of vocational education and training (VET) occupations, the strategic document of the Republic of Croatia, *the National Recovery and Resilience Plan 2021-2026*, outlines goals and budget allocations aimed at increasing the number of students transitioning from VET occupations in economics and trade to gymnasium programs. **Unfortunately, the document missed a historic opportunity to allocate resources and initiate transformative measures for the deficient occupations in VET education within the construction, architecture, electrical, and mechanical engineering sectors, especially in the activities related to increasing student enrolment.**

5.2. Higher level education

Higher education in Croatia in the fields of civil engineering, architecture, electrical engineering science, and mechanical engineering with a focus on renewable energy sources (level 6 and 7 based on *Croatian Qualification Framework* [7]) is overseen by several responsible authorities at the national and regional levels.

The Ministry of Science and Education is the national-level authority responsible for overseeing higher education in Croatia. The Ministry of Science and Education performs administrative and other tasks related to the system of preschool education, primary and secondary education in the country and abroad; national curriculum; textbooks, norms and standards and other conditions for educational work; education development; student standard; inspection control; establishing and supervising the legality of the work of institutions and ensuring financial and material conditions for work in upbringing and education; training of children, young people and adults to acquire technical knowledge and skills and the activities of associations in this area. The Ministry performs administrative and other tasks related to: development of higher education; implementation of national strategies and programs for higher education; ensuring and monitoring financial and material conditions for the work of higher education institutions; preparing and proposing reports on the work and evaluation of higher education institutions and study programs; subsidizing study costs; student standard; monitoring the success of studies and other higher education processes; managing the implementation of the *Croatian Qualification Framework* [7]; management of registers of higher education institutions and register of study programs; management of databases on higher education; encouragement of lifelong learning and higher education of adults and administrative supervision of higher education institutions.

Law on quality assurance in higher education and science (OG 151/22) [8] – On a national level, this Act regulates the internal assurance and improvement of the quality of higher education institutions and scientific institutes, the external evaluation of the quality of higher education institutions and scientific institutes, and the organization and powers of the Agency for Science and Higher Education.

The Agency for Science and Higher Education (Croatian: Agencija za znanost i visoko obrazovanje – AZVO) is responsible for quality assurance and accreditation of higher education institutions and study programs at the national level. AZVO is an umbrella institution, both nationally and internationally recognized, and in charge of encouraging the continuous development of quality assurance in higher education and science, with the aim of permanently improving the quality of higher education institutions and scientific organizations. AZVO is a public institution and an independent and internationally recognized agency which ensures quality in higher education and science, whose srategic decision is aimed at permanent improvement of the quality of all its activities in accordance with the national legislative framework,

standards and guidelines for quality assurance in The European Higher Education Area (ESG), the requirements of the ISO 9001:2015 [9] standard and good practice in the field of quality assurance of higher education and science.

With the aim of renewing full membership in the European Association for Quality Assurance in Higher Education (ENQA) and status in the European Quality Assurance Register for Higher Education (EQAR), during 2021, the Agency for Science and Higher Education passed the international external evaluation procedure carried out by ENQA for the third time. The aim of the procedure is to determine the extent to which external quality assurance procedures in higher education are aligned with Parts 2 and 3 of the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG).

At the regional level, universities and faculties are responsible for implementing and delivering study programs.

Methodology

When approaching the subject of data extraction, the CRO skills RELOAD consortium faced the discrepancy in official registers containing relevant information on the number and field of expertise of higher education institutions in Croatia. In the Register of Scientific Organizations, regulated by the Ministry of science and education, the system of scientific organizations of the Republic of Croatia consists of 191 institutions registered, among which 95 are higher education institutions. The same Ministry is the main authority for the Register of Higher Education Institutions which counts for 133 institutions, while the official browser of study programs under the authority of Agency for Science and Higher Education and University computing centre of University of Zagreb, MOZVAG, counts 130 higher education institutions that implement 1706 study programs.

The methodology used for extracting data on higher education curricula in Croatia in the field of civil engineering, architecture, electrical engineering science, and mechanical engineering with a focus on renewable energy sources involved several steps.

Firstly, the ISVU system [10] was used, which is a national database that provides information on higher education institutions and study programs in Croatia. The list of faculties founded by public bodies, as well as some private institutions, was extracted from this system. The consortium of CRO skills RELOAD used this list as a reference for contacting the faculties due to its credibility – the list is managed by the mentioned Information system of higher education, with the IT support of the Computing centre of University of Zagreb (SRCE), both institutions under the administration of Ministry of Science and Education, and the data that the list contains is verified to be updated in the year 2023. Next, faculties in the fields of civil engineering, electrical engineering science, mechanical engineering, and architecture were selected based on this list. The official webpages of these faculties were then examined to identify the collegiums or subjects that dealt with renewable energy sources. Once the relevant collegiums/subjects were identified, the main professors in these areas were contacted to gain insight into the curricula and the number of students enrolled. This allowed us to gain a better understanding of the skills developed by students in these collegiums and to identify any gaps in the curricula. By contacting the main professors, we were able to gain valuable insight into the programs and courses offered, including the number of students enrolled and the specific skills developed. This information was critical in understanding the level of education and training provided to students in these fields and the extent to which renewable energy sources were integrated into the curricula.

Overall, this methodology allowed us to gather data on the higher education curricula in Croatia in the field of civil engineering, architecture, electrical engineering science, and mechanical engineering with a focus on renewable energy sources. By

identifying the institutions and programs that offered education and training in this area, we were able to gain a better understanding of the level of knowledge and expertise available in Croatia and identify areas for potential improvement.

Data analysis

The purpose of this report is to present the findings of the data analysis of the number of students that study on the faculties of civil engineering, architecture, mechanical engineering, computer engineering and are enrolled on college courses related to building construction, energy efficiency, green construction, use of renewable energy sources, digitization, BIM, energy-efficient lighting, etc. The data was collected by reviewing online available data, and some of the above data were additionally requested from individual institutions. Out of 122 higher education institutions in the ISVU system, 33 that are in the field of civil engineering, architecture, mechanical engineering and electrical engineering, were examined in detail from the data available on their official websites. From that pool, 22 institutions had implemented class curricula that involved energy efficiency, green construction, use of renewable energy sources, digitization, BIM, energy-efficient lighting, and similar courses of interest. Those institutions and the main professors of the courses were contacted in order to provide detail data on the skills that the course is teaching and the number of students who attended the identified courses in the period from the academic year 2018/2019 until the academic year 2021/2022.

Approximately 128 subjects make the data, which include majors orientations, programs, and courses. The analysis focused on three areas - civil engineering and architecture, mechanical engineering, and electrical engineering. Table 36 shows number of institutions, identified data and number of received statistical data and additional information obtained for the three areas (a total of 73 responses were received, which makes up 57% of the sample).

Table 36 Number of institutions that were contacted

Field of expertise	No. of institutions	No. of data	Received information
Civil Engineering and Architecture	9	53	38
Mechanical Engineering	7	49	24
Electrical Engineering	6	26	11
Total	**22**	**128**	**73**

Several programmes have been identified that specifically focus on promoting sustainability, enhancing energy efficiency, harnessing renewable energy sources, and facilitating digitization in the high-level education, as given in Table 37. Summary of all courses

Table 37 Specialized programme in the high-level education

Field	Institution	Study, Programme
Civil engineering and Architecture	Polytechnic of Međimurje in Čakovec	Sustainable Development, professional undergraduate study
		Sustainable Development - Sustainable Construction, professional graduate study
		Sustainable Development - Eco-Engineering, professional graduate study
Mechanical Engineering	Faculty of Mechanical Engineering in Slavonski Brod	Energy, specialist professional study
		Programme Energy plants, graduate study Mechanical Engineering
	University of Zagreb Faculty of Mechanical Engineering and Naval Architecture	Programme Energetics, graduate study Mechanical Engineering, (Process-Energy)
		Programme Thermotechnics and Process Engineering, graduate study Mechanical Engineering, (Process-Energy)
	Polytechnic of Međimurje in Čakovec	Sustainable Development - Thermotechnical Engineering, professional graduate study
Electrical Engineering	University of Zagreb Faculty of Electrical Engineering and Computing	Electrical engineering, undergraduate study (Electrical engineering and information technology)
		Electrical engineering, graduate study (Electrical engineering and information technology)
	University of Zagreb Faculty of Electrical Engineering and Computing and Faculty of Mechanical Engineering and Naval Architecture	Study of energy efficiency and renewable sources in Šibenik
	Faculty of Electrical Engineering, Computer Science and Information Technology Osijek	Electrical engineering, professional study (Electrical engineering) Electrical engineering, graduate study (Electrical engineering)

Enrolment quotas were additionally analysed, Table 38. Information cannot be found in one unique place. The data analysis revealed that there is no significant change in the enrolment quota according to the technical fields that are of interest, Figure 11 and Figure 12. However, there is a slight increase in enrolment quotas for the field of electrical engineering and information technology (Figure 12). It is important to note that this trend may not be present in all parts of Croatia, and caution should be exercised when interpreting the data.

Table 38 Enrolment quotas for specific universities

	Institution	Univeristy	City	2018./2019.	2019./2020.	2020./2021.	2021./2022.
Electrical engineering	Faculty of Electrical Engineering and Computing	University of Zagreb	Zagreb	650	650	730	730
	Faculty of Organization and Informatics	University of Zagreb	Varaždin	710	710	730	730
	Faculty of Electrical Engineering and Computing and Faculty of Mechanical Engineering and Naval Architecture	University of Zagreb	Šibenik	50	50	50	50
	College of Information Technologies			75	75	75	75
	Faculty of Electrical Engineering, Computer Science and Information Technology Osijek	University of Josip Juraj Strossmayera Osijek	Osijek	385	400	400	400
	Univeristy Department of Professional Studies (Electrical Engineering)	University of Split	Split	325	325	325	325
	Faculty of Informatics and Digital Technologies	University of Rijeka	Rijeka	82	82	82	82
Mechanical Engineering	Faculty of Mechanical Engineering and Naval Architecture	University of Zagreb	Zagreb	510	510	510	510
	Mechanical Engineering	University of Josip Juraja Strossmayera Osijek	Osijek	160	160	160	/
	Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture	University of Split	Split	705	705	730	596
	Polytechnic Karlovac		Karlovac	no data available	230	200	200
	University North		Koprivnica, Varaždin	194	240	240	260
	Faculty of Mechanical Engineering in Slavonski Brod		Slavonski Brod	no data available	no data available	no data available	210
Civil Engineering and Architecture	Faculty of Arcitecture	University of Zagreb	Zagreb	167	167	167	167
	Faculty of Civil Engineering	University of Zagreb	Zagreb	240	240	240	240
	Technical Polytechnic in Zagreb		Zagreb	550	550	550	550
	Faculty of Geotechnical Engineering	University of Zagreb	Varaždin	120	120	120	120
	Faculty of Civil Engineering and Architecture Osijek	University of Josip Juraj Strossmayera Osijek	Osijek	220	220	220	220
	Faculty of Civil Engineering, Architecture and Geodesy	University of Split	Split	233	233	233	233
	Faculty of Civil Engineering	University of Rijeka	Rijeka	175	160	160	160
	Faciulty of Technical Studies	University of Rijeka	Rijeka	355	365	365	315
	Polytechnic of Međimurje in Čakovec		Čakovec	105	105	105	105

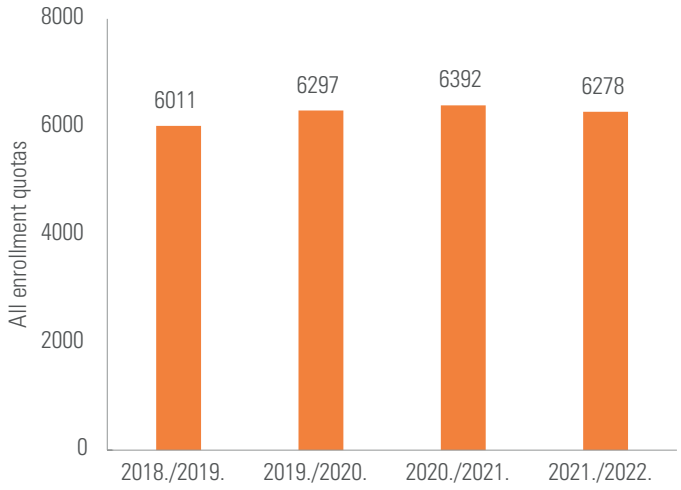

Figure 11 Enrolment quotas

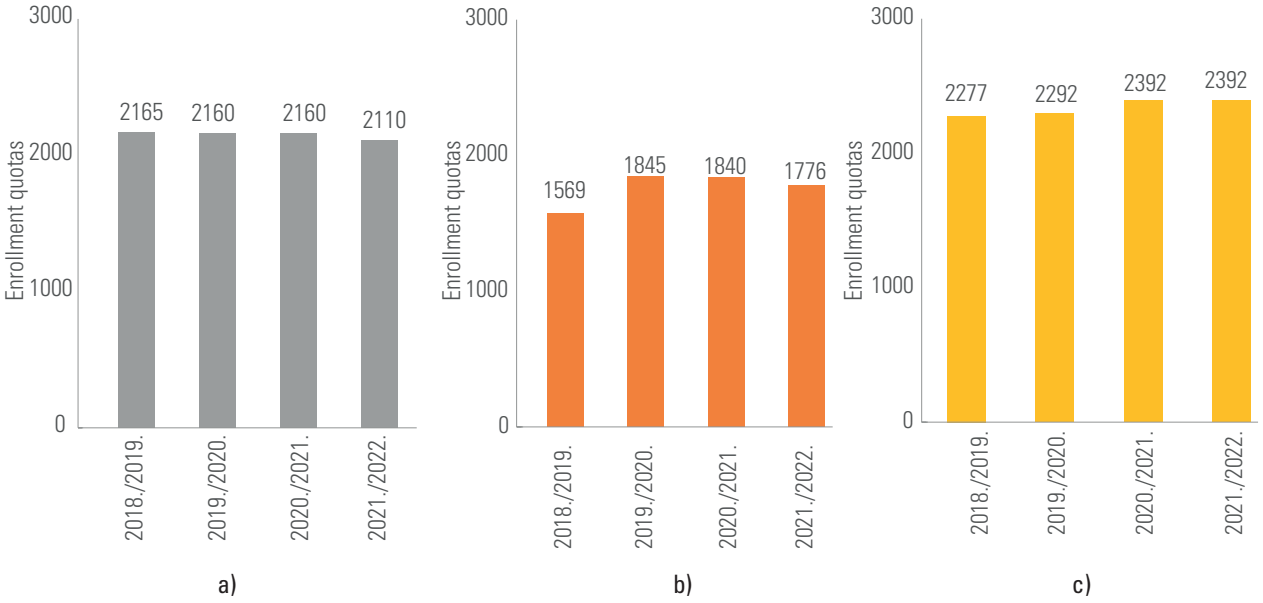

Figure 12 Enrolment quotas ased on the field of expertise: a) civil engineering and architeture; b) mechanical engineering; c) electrical engineering

The Croatian Bureau of Statistics [11]–[14] diligently processes data each year regarding students who have successfully graduated or completed their studies at universities in the Republic of Croatia. This valuable information is collected through a comprehensive questionnaire called the Statistical Sheet for Students who completed their university or professional studies in 2022, available in both printed and electronic formats. The provided Figure 13 presents the compiled data for students who successfully graduated within a span of four years in the technical area. A noticeable decline can be observed in the number of students who successfully completed their education in 2022 (for 10% comparing to year 2020). It is important to highlight that in Figure 11 and Table 38 the given number of students exclusively focuses in technical faculties specializing in civil engineering, architecture, mechanical engineering, and electrical engineering. Therefore, enrolment quotas given in Figure 11 and Table 38 are lower than number of graduated students given in Figure 13.

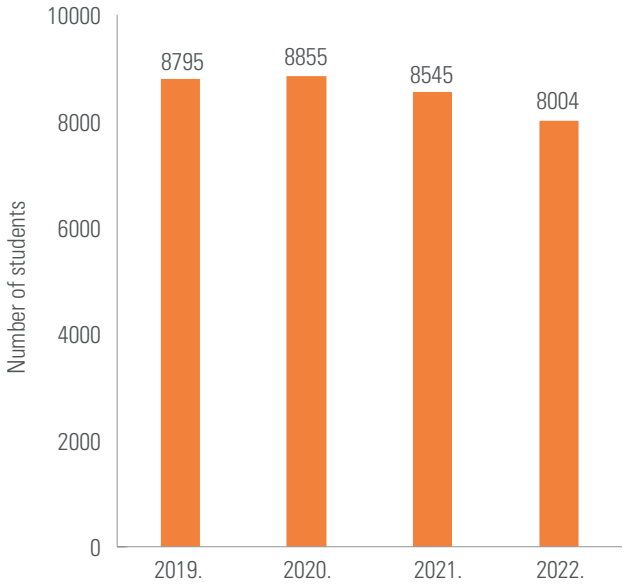

Figure 13 Students that finished/graduated studies in technical science in a 4-year period

Figure 14, Figure 15 and Figure 16 show a trend of enrolment of students in the courses (that provided statistical data) that deal with energy efficiency, sustainability, restoration, renewable energy sources, digitalization, building management in the areas of civil engineering and architecture, mechanical and electrical engineering. It should be emphasized that all the courses are mostly optional, that is, students decide whether they want to enroll or not.

The analysis of Figure 14 showed that more women enrol in the courses related to the energy efficiency, green construction, use of renewable energy sources etc., which can partly be explained by the greater interest of women in enrolling in the architecture studies. However, there is a decline in the number of students enrolling in subjects closely related to energy efficiency. This trend may be attributed to the changing focus of not only students, but also the wider society, to other issues. The assumption is that a series of major earthquakes that hit the area of Zagreb and Banovina made students interested in courses focused on anti-earthquake solutions or reconstruction of earthquake-affected buildings.

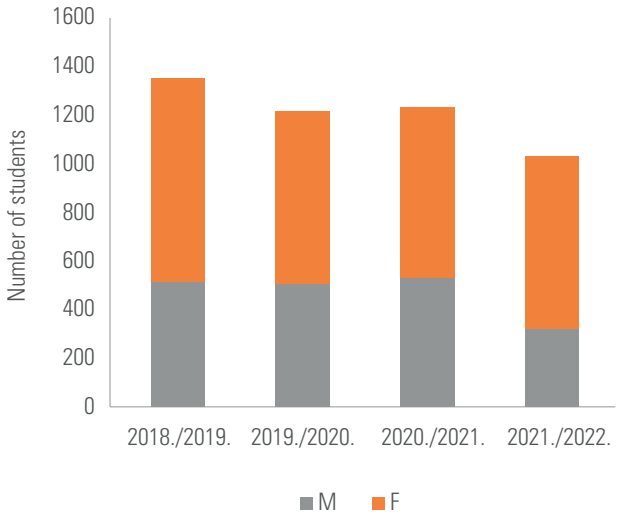

Figure 14 Number of students in the field of civil engineering and architecture (M-male, F-female)

Figure 15 and Figure 16 show the trend of students enrolling in elective courses related to energy efficiency, digitalization, energy management, RES, etc. in the area of mechanical and electrical engineering. In contrast to the field of construction and architecture, it can be seen that more male students are enrolled in the identified courses, which is equal to the trend of enrolled in these faculties/universities. Diagrams given on Figure 15 show a slight decline in students who want to study or enrol in courses related to renewable energy sources. During the first National qualification platform meeting, representatives from various institutions have observed that the aforementioned trend can be attributed to a decrease in students' inclination towards working on the construction sites and their preference for more refined communication skills. Additionally, the relatively lower salaries of engineers compared to those involved in the field of robotics have also contributed to this shift in student preferences.

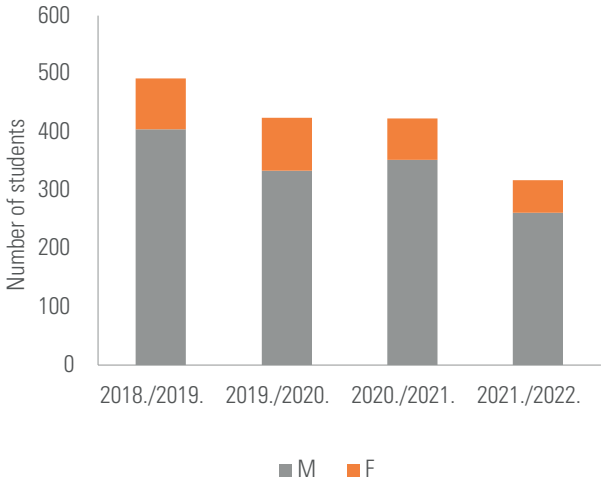

Figure 15 Number of students in the field of mechanical engineering (M-male, F-female)

In the field of electrical engineering, the fewest subjects dealing with energy efficiency were identified compared to the field of civil engineering and architecture and mechanical engineering (Table 36), but a slight increase in the number of students enrolling in the mentioned subjects is visible (Figure 16). Representatives of National qualification platform additionally warned that this trend can change because the lack of attractiveness of work in this area compared to other IT sectors has been noticed.

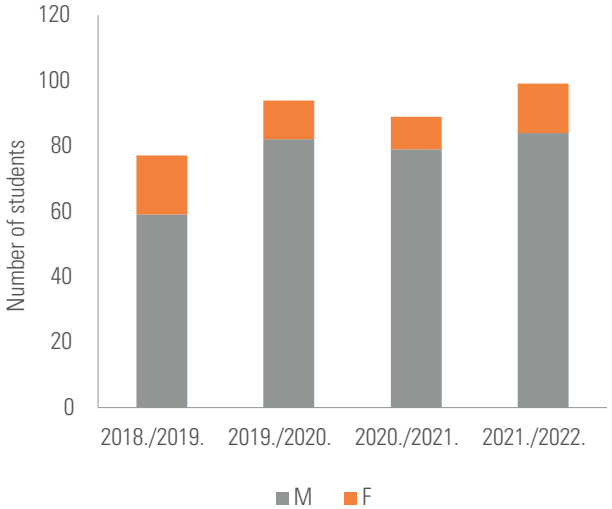

Figure 16 Number of students in the field of electrical engineering (M-male, F-female)

In Table 39 all courses available in Croatia are given.

Table 39 Courses at the institutions available in Croatia

Civil engineering and architecture course	Mechanical engineering course	Electrical engineering course
Green building	Renewable energy sources (6)	Power electronics devices
Sustainable construction (3)	Steam generator	Technological basics of using renewable energy sources
Building physics (10)	Heating, cooling and air conditioning technology	Energy efficient management of buildings (2)
Construction information modelling	Process systems design	Electric lighting
Energy renovations of buildings	Energy efficiency	Energy in buildings
Structural aspects of designing facades	Energy mechanics	Energy sources
Energy rehabilitation of building envelopes	Energy systems	Renewable energy sources
Building installations (5)	Air conditioning technology and automatic regulation	Basics of energy and ecology
Elements of high-rise construction (2)	Thermal measurements	Implementation of Energy Inspection
Energy efficient and sustainable architecture	Plant thermodynamics	Technologies of Renewable Energy Sources
Architectural constructions	Computer modeling of systems in thermotechnics and thermoenergetics	Sustainable electrical energy
Energy efficient buildings	Energy management	Energy Efficiency of Electrical Systems
Construction of Historic Buildings	Energy efficiency in building construction	Energy Inspections and Public Lighting (2)
BIM	Energy in buildings	Thermal applications of renewable energy sources
Revitalization, conservation and restoration of buildings	Energy sources (2)	Energy efficiency
Construction (3)	Heat pumps with renewable energy sources	Ecology and sustainable development
Waste management	Energy efficiency and optimization in buildings	
Introduction to thermal protection and energy saving in construction	Energy certification of buildings	
Environmental Protection	Energy planning	
Fundamentals of energy	Low-carbon and smart buildings	
Structural modelling	Solar heating system	
Construction Technology	Sustainable energy management in smart cities	
Sustainability Architecture	Sustainable thermal and process engineering	
Sustainability of construction	Sustainable use of energy	
Energy certification of buildings	Renewable energy sources in electricity production	
Technical documentation and regulations	Environmental protection	
Computer-aided design (2)	Designing energy plants	
Sustainability of utilities	Energy sustainability and self-sustainability	
Energy and the environment	Energy plants	
Energy efficiency	Maintenance, thermotechnical engineering	
Renewable energy sources	Energy conversion	
Building management (2)	Thermotechnical System Management	
Product Life Cycle Assessment	Computer-aided design	
	Heating and air conditioning (3)	
50 courses	**42 courses**	**18 courses**

Additionally, the contents of the course were reviewed in order to determine the

skills that are acquired after taking the courses, and the number of courses was given for a specific set of skills, Table 40. In the field of civil engineering and architecture 50 courses were identified, in the field of mechanical engineering 42, while in the field of electrical engineering 18. It can be seen that most courses cover skills for implementation of energy efficiency and renewable energy measures in buildings while other skills (deep renovation, digitalization, ZEBs, circular construction and resource efficiency, sensors, building controls and building management system, historical building) are not so covered under courses.

Table 40 Skills achieved through the courses of interest

	Civil engineering and architecture course	Mechanical engineering course	Electrical engineering course
Skills for implementation of energy efficiency and renewable energy measures in buildings.	24	27	14
Skills for delivering deep renovation of buildings, including through modular and industrialised solutions.	11	0	0
Skills for new and existing nearly Zero Energy Buildings (nZEBs) and bridging the gap towards Zero Emission Buildings (ZEBs).	10	5	0
Skills for integration of renewable energy and efficient heating and cooling technologies, including in particular heat pumps roll-out; skills for installers to deliver heating and cooling upgrades as part of renovation projects.	6	15	3
Skills related to whole life carbon (via the assessment of Global Warming Potential), circular construction and resource efficiency, and leveraging the Level(s) framework.	12	2	3
Digital skills supporting greater energy performance of buildings, in particular through an enhanced use of Building Information Modelling.	5	8	2
Skills for upgrading the smartness of buildings for greater energy performance (based on the Smart Readiness Indicator), looking in particular at sensors, building controls and building management system	3	9	2
Skills for energy upgrade of historical (heritage) buildings	3	0	0

In order to see the actual application of acquired knowledge, the evaluation of existing knowledge and skills in the real sector was made as part of the project *BIMzeED Education for zero energy Buildings using Building Information Modeling* (Grant Agreement: 600946-EPP-1-2018-1-IE-EPPKA2-KA). Under BIMzeED project 48 different nZEB skills and 67 BIM skills were identified as important to gain BIM and nZEB knowledge. A survey was conducted on 60 specialists in the fields of BIM and nZEB with more than 10 years of experience. Some nZEB´ and BIM´skills and the respondents' self-assessment of these skills are shown in the Figure 17, Figure 18 and Figure 19. It is noticeable that the grades related to understanding of nZEB principles range from 3,04 (Understand specifics and basic parameters of heating

and cooling) to 3,47 (Understand importance of energy reduction systems in relation to energy performance) while nZEB skills connected to performing, designing, realization, quality assurance and monitoring had a grade less than 3. The situation is even worse in the self-assessment of BIM skills: the grades are less than 3. The overall grade for nZEB was 2,78 and for BIM was 2,47. This points to the necessity of training even for engineers who have experience working in energy efficiency.

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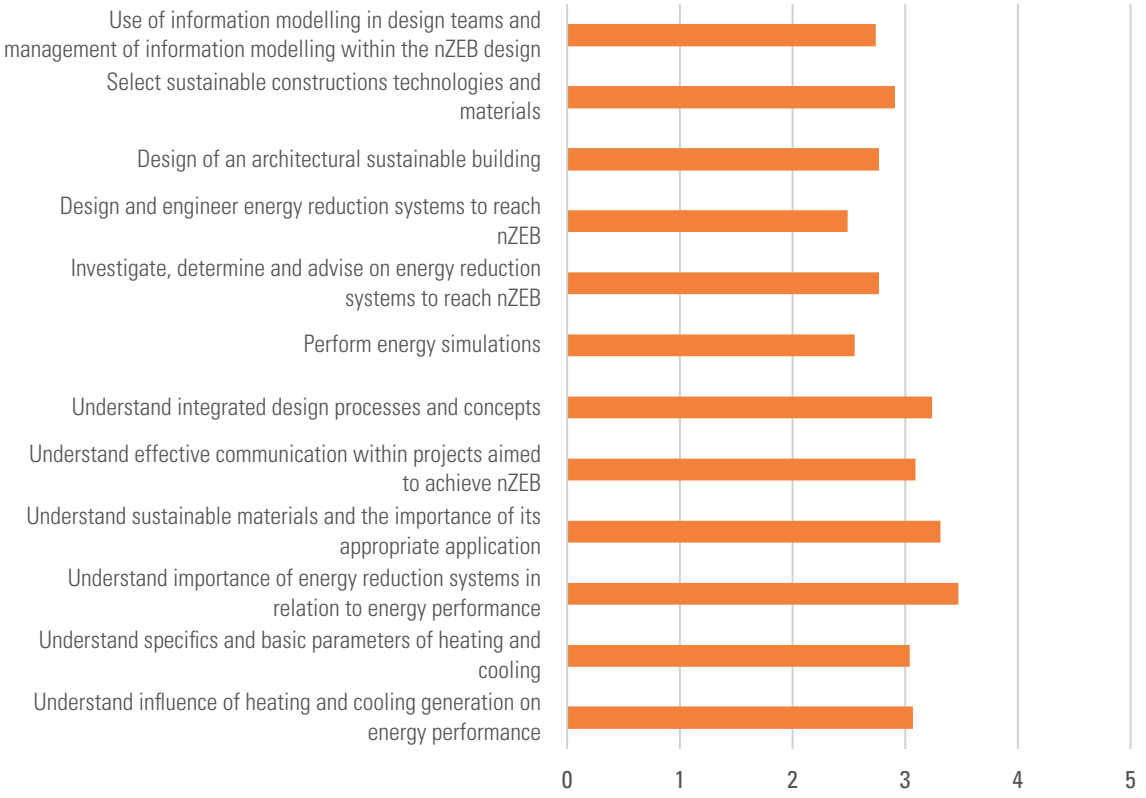

Figure 17 nZEB skills self-assessment (average grade of construction industry based on BIMzeED project)

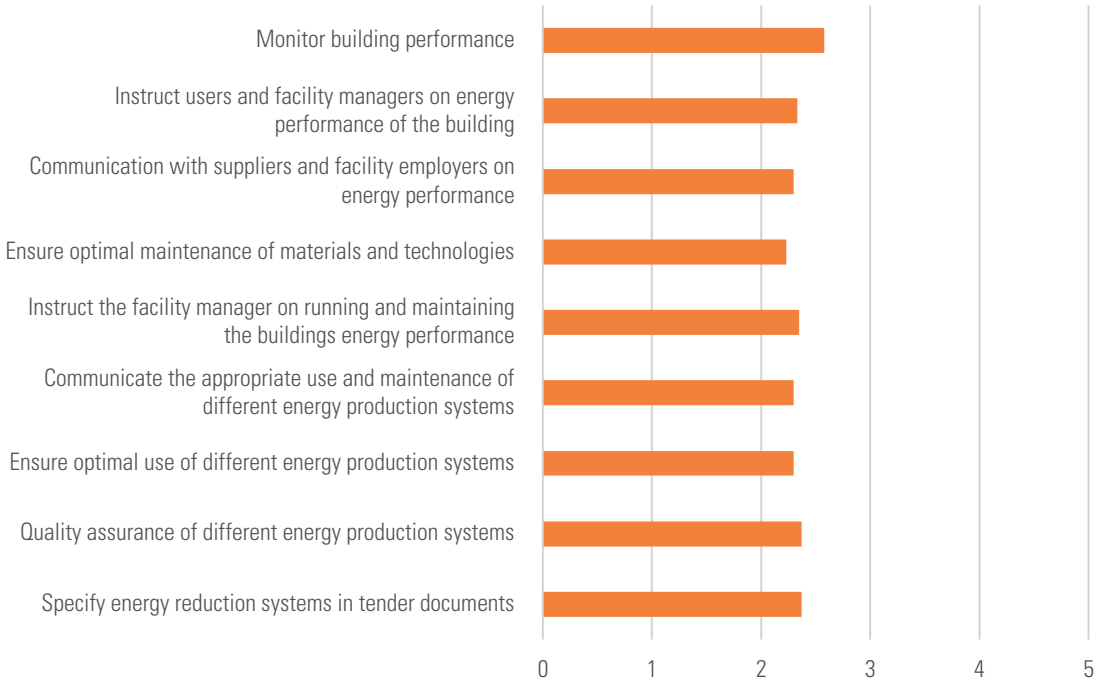

Figure 18 nZEB skills self-assessment (average grade of construction industry based on BIMzeED project)

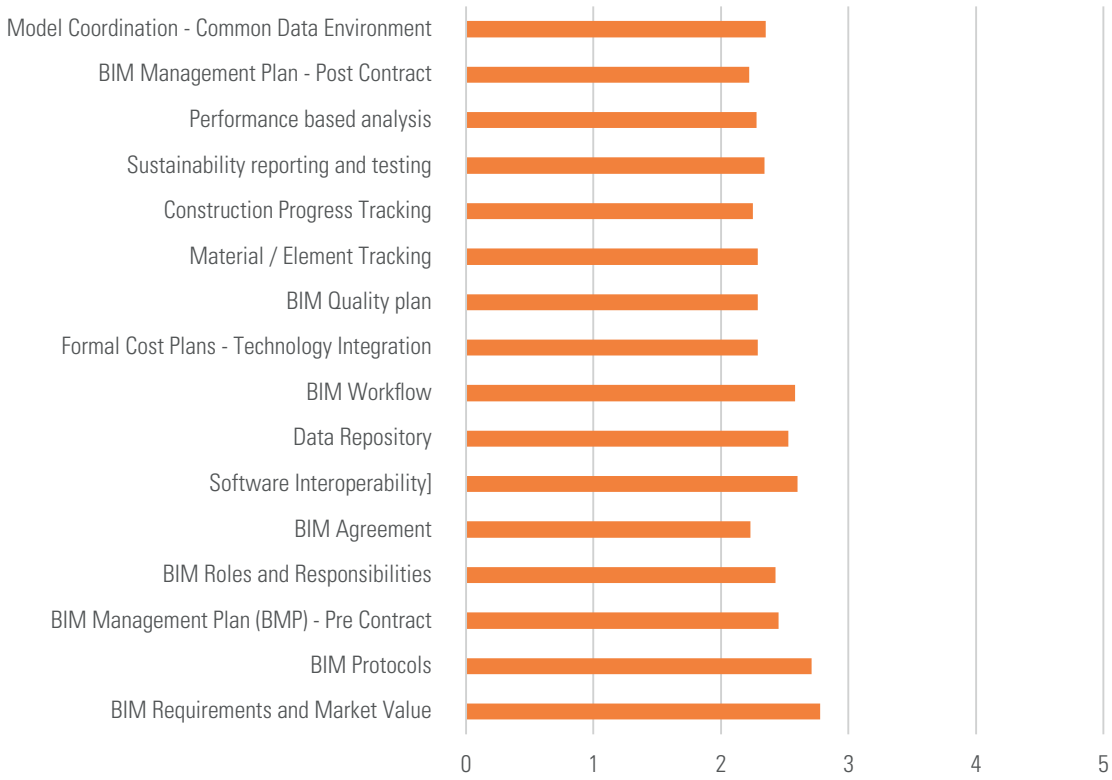

Figure 19 BIM skills self-assessment (average grade of construction industry based on BIMzeED project)

5.3. Lifelong education

5.3.1. Vocational level education

Adult education is the responsibility of the Ministry of Science and Education and the Agency for Vocational Education and Training and Adult Education. The adult education activities are carried out by secondary schools and colleges, which must have approvals for the implementation of each individual program issued by ASOO. It is very difficult to make an analysis in the field of adult education because the data of CES and ASOO non coincide in many points. Maybe the new register or the AZUP database will provide better transparency. AZUP is available on the website of ASOO.

AZUP is a database of adult education institutions, their programs, teachers and students, and was developed in accordance with the *Law on Adult Education* (OG 144/21) [15] and the *Ordinance on Records in Adult Education* (OG 129/08) [16].

The analysis of the situation in the field of adult education was carried out by the Association of Construction Schools using the following methodology: 1) survey of secondary schools; 2) data from the Agency for Vocational Education and Training and Adult Education and 3) data from The Croatian Employment Service (HZZ); 4) data from the Ministry of Physical Planning, Construction and State Assets.

Under the CRO skills RELOAD project, the survey was sent to 78 secondary schools, where 41 schools responded. Based on the survey, 23 of secondary schools provide adult education (55%), Figure 20. The trend of educated adults for a 4-year period in 23 schools is given on Figure 21. 74% of respondents who work in adult education believe that trainers are not qualified respectively that they need additional training, Figure 22. When asked how many schools have qualified trainers in adult education in the construction sector, it was stated that there is a total of 30 qualified trainers. **This points to the need for additional education of the professors and future trainers for education in the field of the energy efficiency, sustainability, deep renovation, digitalization and use of renewable energy systems.**

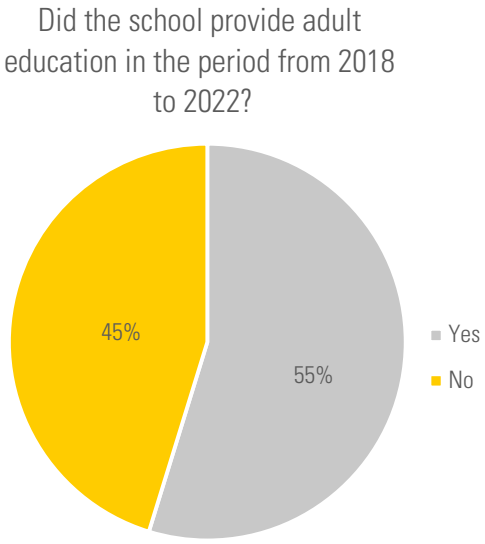

Figure 20 Percentage of schools that provide adult education

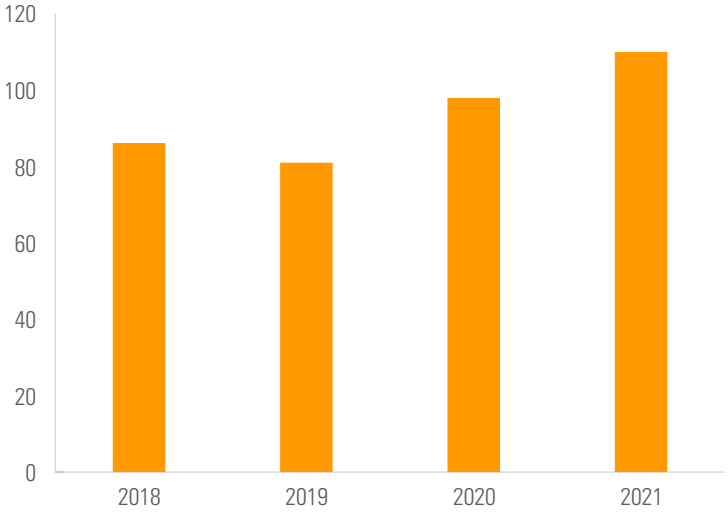

Figure 21 Number of educated workers for 4-year period in schools based on survey

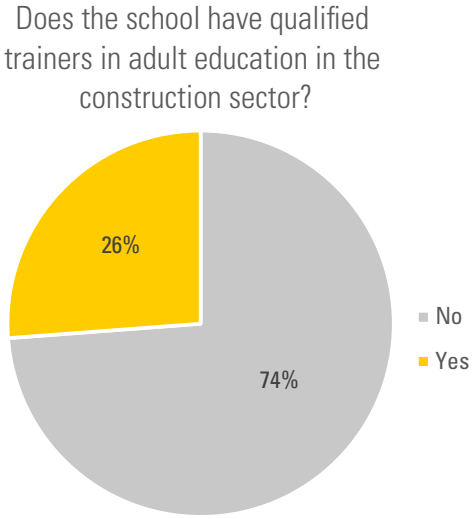

Figure 22 Self-assessment – qualified trainers in adult education

The Agency for Vocational Education and Training and Adult Education submitted data on the number of participants in adult education in the construction sector in the last 10 years. The information available on the website is exclusively provided by adult education institutions. The most common training programs and number of completed participants are given in Table 41.

Table 41 Number of participants in the education programmes

Name of the education sector	Name of the program	Number of completed participants
Construction and geodesy	Rebar worker	809
Construction and geodesy	Facade worker	612
Construction and geodesy	Insulator	319
Construction and geodesy	Tile setter	538
Construction and geodesy	Stone mason	7
Construction and geodesy	Roofer	367
Construction and geodesy	Dry construction fitter	594
Construction and geodesy	Flooring installer	113
Construction and geodesy	Carpenter	1810
Construction and geodesy	Brick mason	1764

The Croatian Employment Service (HZZ) submitted data on the number of referred participants who completed adult education in the construction sector for occupations related to green construction. Adult education can be a part of the measures of active employment policy, either for the purpose of acquiring additional competencies, for the sake of greater competitiveness, or for ensuring the missing workforce on the labor market. It is carried out through training, improvement and retraining programs, most often through public procurement.

Table 42 contains all occupations in the construction and geodesy sector for which training was conducted in the period from 2018 to 2022, while it should be noted that no training was conducted in the period from March 2020 to the end of 2021 in order to comply with the epidemiological measure.

Education programs to which the Employment Service refers unemployed persons are procured through a public procurement procedure, and after the procedure, framework agreements are concluded for a duration of 2 years for each activity individually. The programs are primarily training or improvement programs. Due to the length of the retraining programs, they are not implemented.

The data (Figure 23) shows a larger drop in the number of participants, probably as a result of the Corona virus pandemic and the introduction of the voucher system from 2022. The large number of unemployed adult education participants in 2018 and 2019 is the result of CES measures that largely did not produce the desired results. Very often, unemployed persons referred by the CES for training were insufficiently interested or motivated and did not stay working after the training in these jobs.

Table 42 Number of participants in adult education according to CES data

Year	Name of the program	Number of participants
2018	Construction and geodesy	10520
2019	Construction and geodesy	12907
2020	Construction and geodesy	8880
2021	Construction and geodesy	6588
2022	Construction and geodesy	2831

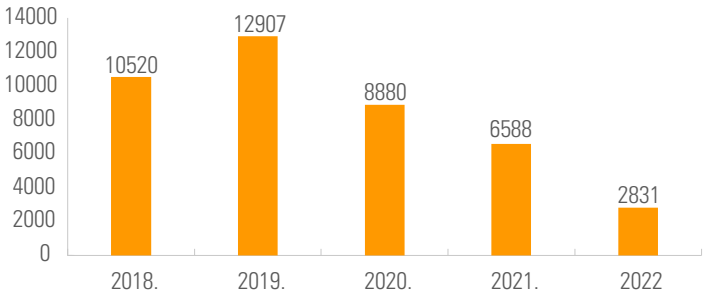

Figure 23 Yearly number of participants in lifelong education according to CES data

In December 2021, a new *Adult Education Act* (OG 144/2021) [17] was adopted in the form of an education modality that would be short and free for workers and employers. According to this Law, both formal and informal adult education programs for the acquisition of competencies necessary for work can be financed through vouchers from the European structural and investment funds and the mechanism for recovery and resilience, with the only condition that they are based on a link with an occupational standard or a set of competencies and a qualification standard or a set of learning outcomes from the HKO Register.

Therefore, by creating adult education programs in accordance with the procedure prescribed by the *Law on the Croatian Qualification Framework* (OG 22/13, 41/16, 64/18, 47/20, 20/21) [18] and the *Rulebook on the Register of the Croatian Qualification Framework* (OG 96/21), [19] it provides long-term funding for the training of workers for energy restoration, earthquake protection and preservation of cultural heritage.

The Ministry of Labour, Pension System, Family and Social Policy, together with its implementing body, the Croatian Employment Service, has established a voucher system and is implementing the allocation of vouchers for the education of unemployed and employed persons, and for the acquisition of green and digital skills. Funding for implementation has been provided as part of the *National Recovery and Resilience Plan 2021-2026* [20]**, with an emphasis on funding education for acquiring green skills.**

From April 2022, with the so-called "standard" education through the public procurement procedure, the Croatian Employment Service is also starting to implement education through vouchers for green and digital skills. In Table 43 the programs that were implemented in 2022 via vouchers are boldly marked, and the stated number of participants refers exclusively to unemployed persons.

Table 43 Yearly number of vouchers shown by the profession

Job	2018	2019	2020	2021	2022	In total
Rebar worker	2		1		5	8
Facade worker	4	5	6			15
Manufacturer and installer of PVC joinery		1	14			15
Ceramist	46	10				56
Tile setter	5	12	8		18	43
Painter	31	2	3			36
Installer of heat pumps					71	71
Installer of photovoltaic systems			6			6
Installer of solar hot water systems	10					10
Installation and connection of solar thermal systems and collectors					59	59
Installation of solar thermal collectors and systems					2	2
Dry construction fitter	112	17	19	7	22	177
Flooring installer	7	1	1			9
Facade worker	5					5
Assistant ceramist	43	23	6			72
Assistant tile setter			5		5	10
Assistant carpenter	1					1
Assistant mason	1	4				5
Painter and decorator			3			3
Carpenter	5	1	2		3	11
Mason	21	2	7		6	36
In total	293	78	81	7	191	650

In order to support educational institutions, as well as to expand the offer of educational programs available to voucher users, programs for the acquisition of green skills published on the website of ASOO have been developed and are available for download by interested educational institutions.

Examples of some educational programs in the green skills sector are:

- Connection and commissioning of heat pumps
- Installation and connection of solar thermal systems and collectors
- Environmental protection in the maintenance of residential and commercial buildings
- Maintenance of power electronics for renewable energy sources
- Installation of solar systems

This voucher system, along with quality programs, can attract the interest of participants and employers and ultimately alleviate the lack of skilled labour. The good side of this measure is that it is based on the good will and interest of participants, both unemployed and employed who are thinking about changing careers and acquiring new knowledge.

According to chapter *3.6 National policies and strategies in the field of continuing education and training,* the Ministry of Physical Planning, Construction and State Assets secured a certification program or an equivalent qualification program for installers of renewable energy systems and construction workers working on the energy efficiency of buildings through several official ordinance (*Ordinance on education and certification system of construction workers working on the installation of building components which affect the energy efficiency of buildings* (OG 67/2017) [1], *Ordinance on requirements and criteria for establishing a quality system for services and works for certification of installers of renewable energy sources - photovoltaic systems* (OG 56/15)

[1], *solar thermal systems* (OG 12/17) [2], *small biomass boilers and furnaces* (OG 12/17) [3] and shallow geothermal systems and heat pumps (OG 12/17) [4]. According to the mentioned regulations, the Ministry is obliged to maintain a database of certified installers of renewable energy sources and construction workers working on the energy efficiency of buildings. Database of certified installers of renewable energy sources shows only 545 certified installers of photovoltaic systems while there were no installers of solar thermal systems, small biomass boilers and furnaces and shallow geothermal systems and heat pumps. **Register of certified construction workers working on the installation of building components which affect the energy efficiency of buildings is not available.**

5.3.2. High level education

Engineer training programs are implemented by Chambers: Croatian Chamber of Civil Engineers, Croatian Chamber of Architects, Croatian Chamber of Mechanical Engineers and Croatian Chamber of Electrical Engineers. The *Law on the Chambers of Architects and Chambers of Engineers in Construction and Spatial Planning* (Official Gazette 78/15, 114/18, 110/19) [21]. The law regulates the basic structure, scope, public powers and membership of the Croatian Chamber of Architects, the Croatian Chamber of Civil Engineers, the Croatian Chamber of Mechanical Engineers and the Croatian Chamber of Electrical Engineers. The quality of the services provided by authorized architects, authorized urban planning architects, authorized engineers and authorized construction managers, i.e. authorized work managers in spatial planning, design and/or expert construction supervision and construction management is ensured by completing and perfecting their knowledge, expert supervision over the work of these persons and with the cooperation of the Chamber and the Ministry. Certified architect, certified urban planner, certified engineer, certified construction manager, and certified construction manager continue to complete and improve their knowledge by continuously monitoring the development of the construction profession and acquiring new knowledge and skills. Professional training for all Chambers is prescribed by the Regulations (adopted by the Chamber) which prescribe the conditions and methods of implementing and monitoring professional training. Table 44 gives number of certified engineers and architects that are obliged to undergo professional training.

Table 44 Number of active certified engineers and architects (status in June 2023)

Certified civil engineers	Certified civil engineers for design and supervision	4805
	Certified construction engineers for professional supervision	13
	Site engineers	3575
	Work engineers	23
/Certified architects	Certified architects	2721
	Certified urban planning architects	500
	Foreign certified architects	23
	Members of the Chamber at rest	1014
	Foreign certified persons for occasional or temporary performance of the architectural profession	7
	Site engineers	156
	Work engineers	5
	Landscape architects	38
Certified electrical engineers	Certified electrical engineers	2061
	Site engineers	1136
	Work engineers	6
	Foreign certified electrical engineers	2
	Foreign construction managers	0
	Foreign works managers	0
	Foreign project managers	0
	Foreign authorized persons for occasional or temporary performance of electrical engineering work	111
Certified mechanical engineers	Certified mechanical engineers	1282
	Site engineers	1007
	Technicians of the mechanical profession	60
	Records of issued EU certificates	17
	Foreign authorized persons in the mechanical engineering profession	24

Each Chamber issues a training program for the existing one- or two-year period, in which the content of professional training is defined. The training includes professional, regulatory and business content. Professional training is intended for people who have passed the professional exam and thus obtained the status of certified engineer/architect. The holder of the professional development program is the Chamber. Apart from Chambers, professional training can be carried out by institutes that have the approval of the *Ministry of Physical Planning, Construction and State Assets fo*r the professional training program (professional organizations, universities, polytechnics and other legal entities).

6 Relevant building skills projects

The European strategic initiative BUILD UP Skills (http://www.buildup.eu/en/skills) [22] was launched by the European Commission in 2011 under the Intelligent Energy Europe Programme to strengthen the qualifications and training of 'the blue collar' workers in the building sector (craftsmen, builders, systems installers). In the first phase of the initiative, all countries involved (EU 28 + Norway and the Republic of North Macedonia) analysed their current situation and made a critical review of the skill gaps of the 'blue collar' workers, in terms of their technical qualifications in energy efficiency as well as their existing curricula. This work led to developing a set of recommendations in the form of National Roadmaps. Croatia was also part of this first phase of the initiative under the project CROSKILLS Build Up Skills Croatia (IEE/12/BWI/457/SI2.623227). Within this project (duration: 2012-2013) two main documents were developed: *Status quo analysis of the building sector in Croatia and skills of construction workers in the field of energy efficiency and renewable sources of energy* [23] and *National roadmap for a lifelong education of construction workers in the field of energy efficiency* [24]. The first Status quo estimated number of workers required for training in order to achieve national energy efficiency objectives (20-20-20 objectives) by the year 2020. It was estimated that 37 600 workers and 250 trainers needed to be trained in order to achieve the Croatian ambitious goal in energy efficiency by the year 2020. Through the activities of the CROSKILLS Build Up Skills Croatia, key national stakeholders were gathered in the frame of National Qualifications Platforms (NQPs) that included all relevant sectors and actors (ministries responsible for construction, energy, labour and lifelong learning; relevant federations and professional associations; institutions and organisations dealing with the Continuous Vocational Education and Training (CVET); accreditation and certification bodies; professional chambers; trade unions; training providers; building industry and financing bodies).

From 2010 until now, in Croatia 18 relevant European and national funded projects were identified tackling education of different stakeholders in the construction sector. Main outputs and project description as well as main information about the project and target groups of each project are given below.

Project and webpage	**INTENSE - From Estonia to Croatia: Intelligent Energy Saving Measures for Municipal housing in Central and Eastern European countries** **Documents available: http://www.intense-energy.eu/ https://www.bef.lv/projekti/intense-3/**
Timeframe	October 2008 - September 2011
Budget & funding source	3,200,501.00 EUR Intelligent Energy Europe Programme and Society Integration Foundation (SIF) project No. IEE/07/823/SI2.500392
Partners	Baltic Environmental Forum in Estonia, Lithuania and Germany Regional Environmental Center Headquarter (with country office Poland and Hungary) in Hungary and the regional offices in Slovakia, Czech Republic, Slovenia, Croatia and Romania, Sofia Energy Agency, Bulgaria, Energy and Environment Center, Germany, Auraplan, Germany, Riga Energy Agency, Latvia, Local Action Group Moravian Karst, Czech Republic, Local municipalities: Muenster (Germany), Frankfurt (Germany), Sapareva Banya Bulgaria), Cesis (Latvia), Saku (Estonia), Elektrenai (Lithuania), Ozarow (Poland), Ruzomberok (Slovakia), Veszprem (Hungary), Ptuj (Slovenia), Koprivnica (Croatia), Samobor (Croatia), Tusnad (Romania)
Brief description of main outputs	INTENSE aimed at transferring intelligent energy saving measures for municipal housing from "old" EU Member States to "new" Member States and Accession countries in Central and Eastern Europe. The project was implemented in 12 countries by 28 partners representing multiplier organisations, municipalities and project experts. Built on a holistic approach for planning of energy optimised housing, the project comprised an analysis of legal preconditions, experience exchange on best practice examples, development and implementation of training programmes (Figure 24a), pilot planning activities at partner municipalities, and public awareness raising. Increased capacities of local authorities were an investment to the future for influencing new housing development at legislative, technical and planning level as well as guiding consumer behaviour towards efficient energy use.
Target professions for education	White collar workers working in municipalities: Engineers, Architects

Project and webpage	Training Personnel towards Operational Energy Efficiency of the Buildings (TRAP-EE) Web: https://iri.uni-lj.si//arhiv/trap-ee/
Timeframe	October 2013 - March 2015
Budget & funding source	150.579,52EUR Lifelong Learning Programme / Leonardo da Vinci / Transfer of Innovation
Partners	Inovacijsko-razvojni inštitut Univerze v Ljubljani (SI-coordinator); HEP ESCO d.o.o. (CRO); Energie:bewusst Kärnten (AT); Goriška lokalna energetska agencija GOLEA, Nova Gorica (SI); Srednja tehniška šola Koper (SI)
Brief description of main outputs	A key identified barrier towards increasing energy efficiency is the lack of qualified personnel responsible for property maintenance, especially within the public buildings (i.e. caretakers) that would be able to implement soft measures for achieving efficient energy use. Up-to-date no training activities for increased operational efficiency in public buildings are offered in Slovenia and Croatia targeting the specific group of caretakers that would address the challenges in hand. The main aim of the TRAP-EE was to develop a training programme to train the caretakers towards achieving operational energy efficiency of the public buildings. The training will reduce the chances that they will inadvertently negatively modify or override building systems essential to maintaining performance
Target professions for education	caretakers

Project and webpage	SEEDPass - Southeast Europe strategic partnership in vocational education and training in Passive House Design for nearly zero energy buildings development Documents available: http://seedpass.oikon.hr/
Timeframe	September 2014 - August 2016
Budget & funding source	269.831,00 EUR Erasmus+ Programme, Key Action 2: Strategic Partnerships No. 1288/2013
Partners	OIKON Institute for applied ecology; SVEUČILISTE U ZAGREBU GRAĐEVINSKI FAKULTET; HELLENIC PASSIVE HOUSE INSTITUTE; ZEPHIR S.r.l.; WOLFGANG FEIST
Brief description of main outputs	Main objective was implementing innovative education curriculum and course in VET for professional architects and civil engineers which empower and build up knowledge needed to design high energy efficient buildings, nZEB, but which also foster skills to achieve the European target 2020, Figure 24b. Professional development opportunities must be provided on national level to be cost-effective. Therefore, our Consortium developed a plan to deliver the course on Passive House design and introduce the certification accordingly. By doing this, the qualifications needed to design high energy efficient buildings, such as nZEB, were more easily recognized on the labour market, and it fostered employment in the building sector, which, due to the European Directive 2002/91/EC 2020 and European Commission's „Action Plan for Energy Efficiency", 2006, has the obligation to adjust traditional building standards to a much higher energy efficient solutions. This partnership resulted in the development of a curriculum and education course 'Certified Passive House Designer' in each of the partner's countries. Once this is implemented at a national level, job seekers will become more visible on the already established international scale demand side.
Target professions for education	White collar workers as trainers: Engineers, Architects, Teachers at VET schools

a) b)

Figure 24 a) Trainings for public authorities under INTENSE project; b) Training of trainers under

Project and webpage	Build Up Skills CROSKILLS II, Build Up Skills CROatia: Strengthening energy efficiency SKILLS and certification schemes for building workers Documents available: https://croskills-reload.grad.hr/hr/dokumenti/
Timeframe	September 2014 - August 2017
Budget & funding source	602.501,00 EUR Intelligent Energy – Europe (IEE) under grant agreement No. IEE/13/BWI/722/SI2.680179
Partners	Faculty of Civil Engineering University of Zagreb, Regional Environmental Center for Central and Eastern Europe, Country Office Croatia, School of Building and Craft of Čakovec, HUPFAS - Croatian Association of Façade Thermal Insulation System Manufacturers, Croatian Chamber of Civil Engineers, Croatian Employment Service
Brief description of main outputs	CROSKILLS consortium developed all comprehensive training materials and training curricula for 6 priority building professions (bricklayers, plasterers, roofers, carpenters, housepainters and drywall fitters) for theoretical part and practical part of the training Figure 25. Consortium established training schemes that are included under Ordinance on the training and certification scheme for building workers who incorporate building parts that have an impact on energy efficiency in the building sector, developed in cooperation with The Ministry of Physical Planning, Construction and State Assets (MPPCSA), which was official approved on 12th July 2017 (OfficialGazette/2017) - https://narodne-novine.nn.hr/clanci/sluzbeni/2017_07_67_1578.html. It includes criteria for potential training providers with all other criteria and requirements as a part of accreditation and certification scheme. It also includes mutual recognition where certified workers under BUILD UP Skills initiative from another country will be recognized in Croatia. Consortium prepared the manuals for trainers and presentation for training of trainers (ToT). 12 Traning centers were established and 61 trainers for plasterers, 61 trainers for bricklayers, 49 trainers for house painters, 34 trainers for drywall fitters, 37 trainers for roofers and 51 trainers for carpenters were trained in order to transfer knowledge to workers. During these 53 pilot actions of workers, 330 participants (80 bricklayers, 95 plasterers, 56 house painters, 22 drywall fitters, 34 roofers and 43 carpenters) finished theoretical and practical part of education, and successfully passed THE exam. Due to the high-quality content and positive feedback from all relevant stakeholder (including trained workers and trainers under CROSKILLS Programme), manuals for trainers and workers were approved as auxiliary teaching materials in the vocational schools in Croatia by the Agency for Vocational Education and Training and Adult Education (21st July 2017). Consortium was included and participated in a working group for developing 4th National Action Plan for Energy Efficiency of the Republic of Croatia for the period 2017 - 2019. As the main result for the project sustainability, under measure H.4 "Energy Efficiency Education".
Target professions for education	White collar workers as trainers: Engineers, Architects, Teachers at VET schools Blue collar workers: bricklayers, plasterers, roofers, carpenters, housepainters and drywall fitters Requirement for education given under Ordinance on the training and certification scheme for building workers who incorporate building parts that have an impact on energy efficiency in the building sector

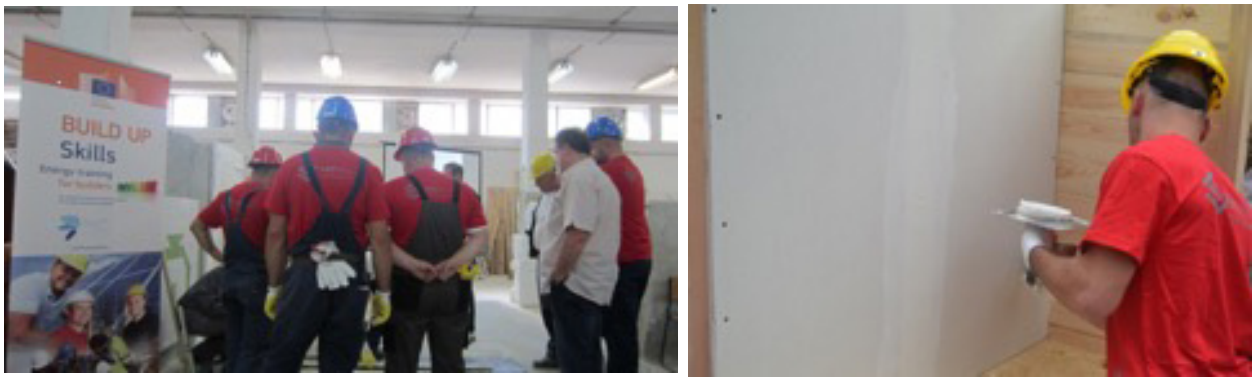

Figure 25 Practical part of education for workers under CROSKILLS II project

Project and webpage	Improvement of the learning system in energy efficiency education
Timeframe	December 2015 – November 2016
Budget & funding source	- Strengthening the capacity of institutions for adult education - phase II, European Public Call
Partners	Faculty of Civil Engineering university of Josip Juraj Strossmayer, Osijek; Udruženje Baranja iz Luga, Učilište Janus Osijek
Brief description of main outputs	The goals of the project include strengthening the College's capacity by modernizing the existing educational program, developing a new education program, strengthening the College's material and personnel capacities and developing intersectoral cooperation, as well as including in the development of qualification/occupational standards. The qualification/occupational standard was developed for the newly created training program Thermal insulator in building construction, and the development of the program was led by the Faculty of Civil Engineering Osijek in cooperation with employers in the construction sector, whose needs and instructions were key in the development of the program. The existing training program, Installer of solar systems, which Janus School has been conducting since 2011, has been modernized by this project, so it can be attended via distance learning (Moodle system).
Target professions for education	installers of solar systems and thermal insulators in buildings.

Project and webpage	The development of higher education occupational standards and qualification standards for the field of sustainable and green construction with the development of a new university degree program in sustainable and green construction with an emphasis on the Mediterranean area
Timeframe	June 2015 – June 2016
Budget & funding source	2,892,581.40 HRK European Social Fund and State Budget of the Republic of Croatia
Partners	Faculty of Civil Engineering, Architecture and Geodesy University of Split
Brief description of main outputs	A completely new study program was developed in accordance with the Croatian qualification framework - Master study program in sustainable and green construction in the Mediterranean area. As the basis of the new study program, the occupational standard (Sustainable Construction Project Manager) and the qualification standard (Master of Sustainable Construction Engineer) were developed.
Target professions for education	Students in high institution

Project and webpage	Net-UBIEP, Network for Using BIM to Increase the Energy Performance https://www.net-ubiep.eu/ https://cordis.europa.eu/project/id/754016
Timeframe	July 2017 - January 2020
Budget & funding source	995,023.00 EUR European Union's Horizon 2020 research and innovation programme, Social Challenges - Secure, clean and efficient energy under grant agreement No. 754016
Partners	Agenzia Nazionale per le Nuove Tecnologie, L'energia e lo Sviluppo Economico Sostenibile, Italy; Centro servizi aziendale scarl, Italy; Viaeuropa competence centre sro, Slovakia; Fundacion laboral de la construccion, Spain; Viesoji istaiga skaitmenine statyba, Lithuania, Sveučilište u Zagrebu Građevinski fakultet,, Croatia; Vilniaus gedimino technikos universitetas, Lithuania; Stichting ISSO, Netherlands; Tallinna tehnikaülikool, Estonia; Ustav vzdelavania a sluzieb, Slovakia; Agencia estatal consejo superior de investigaciones cientificas, Spain; Balance & result organisatie adviseurs bv, Netherlands; Mittetulundusuhing eesti timmitud ehituse tugiruhm, Estonia
Brief description of main outputs	By providing training in building information modelling, the Net-UBIEP project is helping the building sector, building owners and public authorities make energy-informed decisions. The project has developed BIM training, qualification and certification schemes that specifically address the building sector's lack of energy competency. By completing the schemes, a professional will be deemed competent as either a BIM evaluator, facility manager, coordinator, expert or user, Figure 26. All Net-UBIEP materials are publicly available via the project website in eight languages (Croatian, Dutch, English, Estonian, Italian, Lithuanian, Slovakian and Spanish). An e-learning course is also available for technicians, who typically do not have the flexibility to follow a face-to-face course. Although a work-in-progress, when complete, the project hopes to have increased the energy performance competency of over 2 000 building professionals. Project researchers are encouraging Member States, universities and professional associations to promote the uptake of the Net-UBIEP qualification courses. The Net-UBIEP team worked with public administrations to make the BIM training and certification a requirement within the public procurement process. Finally, on 28 October 2019, Net-UBIEP signed a Memorandum of Understanding with Building Smart International (bSI), allowing for the inclusion of the Net-UBIEP qualification scheme as a new module of the bSI Individual Qualification Programme. This is significant because any country in the world can access the Net-UBIEP qualification through its national bSI chapter.
Target professions for education	Public Administrations, Professionals (Engineers / Architects), Technicians (Installers / Maintainers) and Tenants

Figure 26 Trainings for professionals under the Net-UBIEP project

Project and webpage	Fit-to-NZEB, Innovative training schemes for retrofitting to nZEB-levels http://www.fit-to-nzeb.com/
Timeframe	June 2017 - June 2019
Budget & funding source	1,013,848.75 EUR European Union's Horizon 2020 research and innovation programme, Social Challenges - Secure, clean and efficient energy under grant agreement No. 754059
Partners	Center for Energy Efficiency EnEffect, Bulgaria; University of Architecture, Civil Engineering and Geodesy, Sofia, Bulgaria; SEVEn, the Energy Efficiency Center, Czech Republic; Czech Technical University in Prague, Czech Republic; Association Cluster for Promoting Nearly Zero Energy Buildings, Romania; Technical College for Architecture and Public Works, Romania; Passive House Academy, Ireland; University of Zagreb, Faculty of Civil Engineering, Croatia; Zero Energy and Passivhaus Institute for Research, Italy; Hellenic Passive House Institute, Greece; Technical University, Austria
Brief description of main outputs	Fit-to-nZEB project aimed to increase competence and skills of the building professionals in the field of deep energy renovation (DER) in the target countries (Czech Republic, Romania, Bulgaria, Italy, Croatia, Ireland and Greece), Figure 27. The project consortium developed an innovative European Qualification Framework (EQF) level 3-7 training schemes for retrofitting buildings up to NZEB-levels, implemented under the project framework. Special focus is given the development of a design-focused training programmes on deep energy building renovation for higher education establishments (EQF level 6-7) specializing in architecture and energy system, developing a training programme on DEP in the professional high schools (EQF level 3-5) in Construction and Electrical engineering and energy sector and developing training programmes for acquiring qualification on part of profession (specialization, or similar qualification according to each national qualification framework), to be used by the vocational training centres (EQF level 3-4). The Fit-to-nZEB project delivered all necessary requisites for the introduction of educational content on DER of buildings in the curricula at all levels of the educational and training system in South-eastern Europe
Target professions for education	All relevant professions from professional directions "Construction" and "Electrical engineering and energy sector", EQF 3-7

Figure 27 Training of HEI students under the Fit-to-NZEB project

Project and webpage	BIMzeED - Education for Near Zero Energy Buildings Using Building Information Modelling https://bimzeed.eu/
Timeframe	November 2018 - May 2022
Budget & funding source	955,633.00 EUR Erasmus+ under grant agreement No. N. 600885-EPP-1-2018-1-ES-EPPKA2-SSA-B
Partners	Limerick Institute of Technology, Ireland; Tipperary Energy Agency, Ireland; University of Zagreb Faculty of Civil Engineering Croatia; Emi; Óbuda University, Hungary; Institut de Tecnologia de la Construcció de Catalunya, Spain; CIM – UPC, Spain; Architects' Council of Europe, Belgium; Northwest Regional Energy Agency, Croatia
Brief description of main outputs	The BIMzeED project focused on the training needs for the current and future construction industry with the main purpose to encourage 1) better employability 2) low-carbon growth, 3) green and NZEB skills 4) increase in youth employment. The construction industry across Europe is facing major challenges in achieving energy efficiency targets, in particular for near Zero Energy Building NZEB, but they are also experiencing a digital revolution, with Building Information Modelling (BIM). The BIMzeED project intends to improve the human-capital basis of the construction sector, which is identified as a strategic initiative by the European Commission, acting on HEIs and VET systems in Europe. The BIMzeED project supported the construction industry, through education and training to upskill on technical innovation and digitalization, Figure 28. BIM can assist with achieving cost effective NZEB construction. BIMzeED developed and piloted 12 Learning Units within the aim of increasing understandings of BIM/NZEB within existing construction training curricula, thus capitalizing on the opportunities that environmental protection can offer to the labour force. BIMzeED trained and upskilled 1840 educators at European HEIs and VETs by piloting the new learning resources and training materials, which are made available as transferrable Learning Units. BIMzeED piloted 12 Learning Units with over 500 construction students, site managers, craftworkers and other experienced operatives therefore improving their employability.
Target professions for education	All relevant professions from professional directions "Construction" and "Electrical engineering and energy sector", EQF 3-7

Figure 28 Training of HEI students under the BIMzeED project

Project and webpage	PROF-TRAC, PROFessional multi-disciplinary TRAining and Continuing development in skills for NZEB principle http://proftrac.eu/open-training-platform-for-nzeb-professionals.html
Timeframe	March 2015 – February 2018
Budget & funding source	1,499,871.25 EUR European Union's Horizon 2020 research and innovation programme under grant agreement No. 649473
Partners	HuygenInstallatieAdviseurs, Netherlands; Federation of European Heating and Air conditioning Associations, Netherlands; Architects' Council Europe, Belgium; Housing Europe, Belgium; ISSO (Dutch Knowledge Centre), Netherlands; Valencia Institute of Building, Spain; Czech Technical University Prague, Czech Republic; Aalborg University, Denmark; Croatian Chamber of Mechanical Engineers, Croatia; Spanish Technical Association of HVAC and Refrigeration, Spain; Dutch Society for Building Services, Netherlands; Chamber of Architecture and Spatial Planning of Slovenia, Slovenia; Italian Chamber of Architects, Italy; Czech Chamber of Chartered Engineers and Technicians, Czech Republic; Danish Society of Heating, Ventilating and Air Conditioning Engineers, Denmark
Brief description of main outputs	Main goal of the project was to develop and maintain education platform for dedicated trainings and continuous development for professionals in nZEB construction and retrofitting. The project had 4 main outputs: (1) to map the professions concerning nZEB construction and retrofitting including a mapping of the required specific skills versus the present available skills; (2) to develop an Open Training Platform including methods for a systematic and sustainable access to knowledge; (3) to develop a Train the Trainers program for the developed qualification scheme and (4) to develop a depository of the training material for use in education and post-initial education.
Target professions for education	White collar workers: Architect, structural engineer, Civil engineer, construction engineer, mechanical engineer; Energy Engineer; Building Automation Engineer; Electrical Engineer / ICT Engineer; Project Manager; Cost Expert; Cost Engineer; Manager of Building Process; Facility Manager; Technical Energy Engineer; Procurer, Chief Procurement Officer; Project Developer

Project and webpage	EN-EFF - New concept training for energy efficiency https://keep.eu/projects/25978/New-concept-training-for-en-EN/
Timeframe	August 2017 – November 2018
Budget & funding source	177,782.50 EUR 2014 – 2020 INTERREG V-A Hungary – Croatia
Partners	Hrvatska gospodarska komora Županijska komora Varaždin, Croatia; Somogy Megyei Vállalkozói Központ Alapítvány, Hungary; Pécs-Baranyai Kereskedelmi és Iparkamara, Hungary; Zala Megyei Vállalkozásfejlesztési Alapítvány, Hungary; PORA Regionalna razvojna agencija Koprivničko-križevačke županije, Croatia; Javna ustanova za razvoj Međimurske županije REDEA, Croatia
Brief description of main outputs	Project has contributed to the education and vocational training for skills and lifelong learning by developing joint training scheme of implementation of "nearly Zero-Energy Buildings" (nZEB) principles. Specific objective was creation, testing and assessment of new innovative syllabus and preparation of educational didactical materials for implementation of practical training for teachers and professionals based on nZEB recommendation. The Energy Performance of Buildings Directive (EPBD) in Article 9 introduced nZEBs as a "building that has a very high energy performance „and future requirements have to be implemented from 2019 for public buildings and from 2021 for all new buildings. As a specific output two new syllabuses were developed on nZEB by this project.
Target professions for education	Vocational secondary construction school teachers

Project and webpage	BUS-GoCircular, Stimulate demand for sustainable energy skills with circularity as a driver and multifunctional green use of roofs, facades and interior elements as focus https://busgocircular.eu/
Timeframe	1 September 2021 - 29 February 2024
Budget & funding source	999,893.75 EUR European Union's Horizon 2020 framework programme for research and innovation under grant agreement No 101033740.
Partners	Stichting circle economy, Netherlands; Building Changes support BV, Netherlands; Fondatsiya Tsentar za energiyna efektivnost – ENEFEKT, Bulgaria; Universitet po architektura stroitelstvo I geodezija, Bulgaria; Ceske vysoke uceni technicke v Praze, Czechia; Institut cirkularni ekonomiky ZU, Czechia, Intituto Valenciano de la edificacion fundacion, Spain; Fereracion Valenciana de empresarios de la construccion, Spain; Sveučilište u Zagrebu Građevinski fakultet, Croatia, EMI Epitesugyi minosegellenorzo innovacios nonprofit KFT, Hungary
Brief description of main outputs	The overall aim of BUS-GoCircular is to address and overcome the challenges of the stimulation of demand for green energy skilled workforce, along with hands-on capacity building to increase the number of skilled workforce across the value chain. BUS-GoCircular will achieve this objective by developing and implementing a circular construction skills qualification framework with a focus on multifunctional green roofs, façades and interior elements. This is worked out in the following five specific qualitative objectives: (1) developing a circular construction skills qualification framework; (2) developing recognition schemes and conducting pilot courses (Figure 29), (3) improving the reputation of the construction sector and attracting women and youth to circular skills professions; (4) stimulating market demand for circularity skills and (5) expanding BUS-GoCircular at national and EU-level by developing and implementing a communication and replication strategy.
Target professions for education	White collar workers: Architect, Civil Engineer, Mechanical Engineer, Electrical Engineer, Construction Engineer, Environmental engineer, Data analyst (Software Engineer), Material Purchaser (material scouts), Project manager, Project developer, Onsite Manager (building process), Building owner/ Operator, Financial manager, Procurer co-ordinator (Tenders), Landscape Architect, Building energy consultants, Policy maker for building, Green Public Procurement (GPP) advisor in construction. Blue collar workers: Insulation Installers, Plasterer, Facade worker, Roofers, Landscaper (roof and facade), Plumber, Electrical installers and technicians, Renewable energy systems installers (electric), Renewable energy systems installers (thermal), Heat pump installers, Demolition/Deconstruction auditors, Repair and maintenance operatives, Ventilation installers, Painter and decorator, Wood manufacturer and finisher, Carpenter, Window installers / glazers, Stonecutter and mason, Bricklayer, Green Roofers

Figure 29 Training of trainers (white collar workers) under the BUSGoCircular project

Project and webpage	nZEB Ready, Enhancing Market Readiness for nZEB Implementation https://nzebready.eu/
Timeframe	September 2021 – August 2024
Budget & funding source	1,098,525.00 EUR European Union's Horizon 2020 research and innovation programme under grant agreement No. 101033733
Partners	Institutul național de cercetare-dezvoltare în construcții, urbanism și dezvoltare teritorială durabilă urban-incerc, Romania; Regional Energy Agency North, Croatia; Pro-nZEB cluster, Romania; National Laboratory of Energy and Geology, Portugal; Center for Energy Efficiency EnEffect, Bulgaria; Research and Innovation Centre Pro-Akademia, Poland; ICLEI – Local Governments for Sustainability, Germany; Technical University of Civil Engineering of Bucharest, Romania
Brief description of main outputs	The project aims to act at market level in order to stimulate the demand for energy-related skills of construction workers and specialists in the involved countries and beyond and to increase the market readiness for an effective nZEB implementation: (1) by addressing the key identified barriers of nZEB implementation in focused markets, (2) by supporting the enhancement of skills framework by new market driven mutual recognition training and certification scheme for nZEB deployment that will facilitate the necessary legislative changes and (3) through development and communication of toolboxes, tailored guidance and practical support to engage home owners and public authorities to reach the nZEB benefits.
Target professions for education	All stakeholders: Building Owners and Investors; Construction Workers; Experts, Designers and Auditors; Financial Institutions; Knowledge Providers; NGOs and Civil Groups; Producers and Suppliers; Public Authorities; Real Estate; Students

Project and webpage	REACT, A digital approach to qualifying technicians in Energy Efficiency in Buildings https://reactproject.eu/
Timeframe	September 2019 – December 2021
Budget & funding source	284,475.00 EUR European Union's ERASMUS+ under grant agreement No. 2019-1-PT01-KA202-061281
Partners	OesteSustentável, Regional Energy and Environmental Agenc, Portugal; Regional Energy Agency North, Croatia; ISQ e-learning, Portugal; Instituto de soldadura e qualidade, Portugal; Kentro erevnon notioanatolikis evropis astiki mi kerdoskopiki etaireia, Greece
Brief description of main outputs	Under the project a curriculum was developed that comprises Professional Profile: Competence Matrix for the qualification (level EQF 4), detailing for the four Competence Units (Basics of Energy Efficiency in Buildings, Technologies for Energy Efficiency in Buildings, Methodologies for the application of Audit Methods and Monitoring of Energy Efficiency in Building) were developed. Each Competence Units consist of learning objectives, learning outcomes workload, contact hours and external resources.
Target professions for education	EQF level 4

Project and webpage	BIMcert, 1. Construction skills, 2. Energy efficiency, 3. Regulating supply chains, 4. Tackling climate change
Timeframe	March 2018 – January 2020
Budget & funding source	1,242,137.75 EUR European Union's HORIZON 2020 under grant agreement No. 785155
Partners	Belfast Metropolitan College, United Kingdom; Instituto superior technico, Portugal; Private scientific institution, institute for research in environment, civil engineering and energy, Skopje, North Macedonia; Energy Institute Hrvoje Požar, Croatia; Future analytics consulting limited, Ireland; Construction industry training board, United Kingdom; Technological university Dublin, Ireland
Brief description of main outputs	The BIMCERT consortium identified the implementation of an online model of integrated, appropriate certification and accreditation that standardises and combines qualifications and skills around BIM, associated technologies and Green construction (sustainable construction, energy savings and efficiency, renewables) as the method by which Europe's construction skills shortage can be rapidly filled. Under the project 32New Curriculum Modules have been developed and the BIMcert Platform has been set up.
Target professions for education	-

Project and webpage	CEN-CE, CEN standard Certified Experts, EU-wide qualification and training scheme based on EPBD mandated CEN standards https://www.cen-ce.eu/
Timeframe	June 2018 – November 2020
Budget & funding source	824,883.92 EUR European Union's Horizon 2020 research and innovation programme under grant agreement No. 785018.
Partners	Scientific and technical centre for buildings, France; Environment and building energy efficiency, Slovakia; the Federation of European heating, ventilation and air conditioning associations, Belgium; University of Zagreb, Faculty of mechanical engineering and naval architecture, Croatia; Laurent Socal, Italy
Brief description of main outputs	The aim of CEN-CE was to offer training and a qualification scheme for middle and senior level professionals. HVAC professionals play an important role in implementing energy efficient solutions, especially when renovating buildings where HVAC systems are often replaced or upgraded in shorter intervals. HVAC professionals have (1) to improve significantly the energy performance and switch to low carbon renewables, (2) upgrade installations to be "2050 compatible" (avoid lock-in effect by sub-optimal installation in new buildings and in renovations, (3) provide a reliable estimation of the real impact of the new installed or upgraded installation and (4) design for performance and communicate on performance. The CEN-CE training scheme has developed training materials for a total of 17 CEN standards on heating and domestic hot water systems, renewables, economic evaluation procedures (global costs, payback period), and measured energy and inspection. The overarching standard EN ISO 52000-1 is also included in the CEN-CE training to provide a first look on the holistic approach and way of aggregation of partial calculations in the overall energy performance indicators. For each standard a complete and complementary set of training supports have been developed in multiple languages (English, French, Italian, Croatian, Slovak): teaching presentations, a handbook to easily understand the calculation procedures and an Excel tool to perform hourly calculation during training. During the project, the CEN-CE scheme modules and associated training materials have been tested during several CEN-CE pilot training sessions in Italy, Croatia, Slovakia. Almost 100 HVAC professionals have already been qualified on one or multiple CEN-CE modules and more than 200 attendees have benefitted from CEN-CE training. The CEN-CE has developed self-paced 100% online training courses that anyone can do at the speed that suits them and their business needs. The CEN-CE Learning Management System (LMS) is a central on-line platform based on Moodle technology with a search feature to find the adequate course.
Target professions for education	HVAC professionals: EQF level 4 – installers, EQF levels 5 & 6 – engineers, architects, national calculation methodology developers (Accredited experts for national calculation methodologies, issuing national EPCs; experts for voluntary certification schemes; energy auditors; consultants on EE; designers, architects interested in calculation of EPB; university teachers, researchers, calculation methodologies developers; installers, all senior workers active on the building site, quality assessors, building managers, etc.; manufacturers)

Project and webpage	CPD4GB Continuous professional development for green building https://cpd4gb.com.hr/
Timeframe	March 2018 – February 2020
Budget & funding source	824,883.92 EUR European Social Fund under grant agreement UP.04.2.1.02.0127
Partners	Croatian Engineering Association, Croatia Council for Green Building, Croatian Association of Civil Engineers, University of Zagreb Faculty of Agriculture, Faculty of Architecture, University of Zagreb, University of Zagreb Faculty of Civil Engineering and University of Zagreb Faculty of Forestry
Brief description of main outputs	This project aimed to respond to the challenges of sustainability and environmental protection in the field of construction by establishing a socially useful learning program for green construction, which will give students the opportunity to learn and, through work with mentors on relevant projects, apply the acquired knowledge and skills and develop professional competences for green construction. The main goal of the project was to train students to work in the field of green construction, to establish a sustainable program of socially useful learning, and to strengthen the professional and analytical capacities of partner associations, Figure 30.
Target professions for education	Universities and students (white collar workers)

Figure 30 Work with students under CPD4GB project

Project and webpage	Establishment of the National Training Center for Near-Zero Energy Buildings (nZEB) https://www.nzebcentar.hr/
Timeframe	May 2021 – April 2024
Budget & funding source	1,600,000.00 EUR Energy and climate change as part of the Financial Mechanism of the European Economic Area for the period 2014-2021.
Partners	Energy institute Hrvoje Požar, Croatia; University of Zagreb Faculty of Civil Engineering, Croatia
Brief description of main outputs	This project, therefore, aims to include all key stakeholders in the process of nZEB building renovation and through a pilot action to show them the benefits of building renovation according to the nZEB standard. The project aims to prove that the nZEB approach is an optimal and cost-effective solution for the renovation of public buildings. The pilot action is a concrete comprehensive renovation of the business public building of the Hrvoje Požar Energy Institute. Comprehensive renovation, in addition to energy renovation measures of the building, will also include measures to increase safety in case of fire, measures to ensure healthy indoor climate conditions and measures to improve the fulfillment of the basic requirement of mechanical resistance and stability of the building, especially to increase the seismic resistance of the building. This pilot investment will also be a demonstrative example of modern technologies that are installed during the renovation of existing buildings according to the nZEB standard and which make the buildings 'smart', namely the electrification of the heating and cooling system, a new lighting system, the integration of renewable energy sources and e- mobility in the building and complete digitization of all technical subsystems used by the office building. With this pilot action, the project responds to the double challenges of green and digital transition.
Target professions for education	White and blue collar workers

Project and webpage	GREENCO, Education for GREEN transformation of COnstruction sector
Timeframe	September 2023 – August 2026
Budget & funding source	1,600,000.00 EUR ERASMUS-EDU-2022-PI-ALL-INNO
Partners	University of Zagreb, Faculty of civil engineering, Croatia; Centre of Education Lolland Falster, Denmark; Construction Technical School in Zagreb, Croatia; Holcim Innovation Centre, France; Sustainable Community Development (ODRAZ), Croatia; Technical University of Denmark, Denmark, Sepgra, Croatia; Institute for material testing, Serbia
Brief description of main outputs	Green transformation of the built environment is only possible through education and mobilization of all skill and organizational levels within the construction workforce, from the engineering (vocational) level to the higher managerial (PhD) level. The main goal of the project is to implement a comprehensive set of cross-sectoral activities and tackle the mismatch between the current education curricula and market demand regarding digital and green skills in the construction sector in order to speed up its green transformation. The project is based on the following activities: 1) for the sensibilization of vocational level students about the importance of green building and sustainable development of the construction sector, handbooks will be made as well as workshops on environmental reporting, training critical number of teaching professionals in vocational schools; 2) for the in-depth education of master level students a new curricula "Green building" will be implemented, in addition to dedicated workshops and training in software use to perform quantitative environmental calculation; 3) to enhance the innovation management skills and to increase the possibility for future green business creation in the sector for the PhD level students will be organized workshops, bootcamps and summer schools; 4) to simulate the decision making within a company, a service learning event will be held with all three educational levels participating and jointly working on a sustainable solution for a local challenge present in their immediate environment. Through tailor-made activities, each targeted occupational/education level group will be trained for their active role as co-creators in green transformation of the construction sector, securely paving the way towards the industrial climate neutrality by 2050, but also serving as a blueprint for a possible future educational – entrepreneurial partnership, designed for answering societal and environmental challenges.
Target professions for education	VET education, Master and PhD Students

Based on literature and available information review, it was noticed that there are no projects that specifically deal with horizontal principles for attracting women in the building renovation and construction sectors. But it is necessary to highlight certain projects that had a significant impact in this area where women were identified as target group: project *raSTEMo: STEM development in the civil society organizations (*https://www.rastemo.com.hr/), project *ASAP, Autonomous System for Assessment and Prediction of Infrastructure integrity* (https://asap-project.com/en/) and project The nZEB Roadshow (https://www.nzebroadshow.eu/). Within these project, specific activities (innovation camps for women within raSTEMo, several workshops for the 7th and 8th grade of elementary school under topic "*Construction, robotics and computing are also women's jobs*" as a part of ASAP project and different promotional activities under mobile nZEB house MUZA) promote a gender-aware policy, removing stereotypes about "men's jobs" and presenting a different perception of gender in construction sector, Figure 31.

a) b)

Figure 31 a) Innovation camp for women in Gospić under project RaSTEMo; b) workshop for students from Glina Elementary school under ASAP project

7. Skills gaps between the current situation and the needs for 2030

7.1. The current situation in construction - the volume of construction works and the movement of the workforce

Energy renovation and investments in renewable energy sources are part of the overall economic activity undertaken in the construction sector. In order to predict the needs of the construction sector to achieve the EU 2030 goals, it is necessary to obtain a detailed insight into the capacities of the sector, the movement and annual trends of construction activity by year, the entry of workers into the sector, i.e., the need for labour and the engagement of labour at construction sites by year. We will increase the assessment of the usual movement of construction activity, in comparison with the movement of labour (entry and exit) to the market, and the needs for carrying out the building fund in the context of energy efficiency in order to obtain an approximation of the need for labour to achieve the goals of 2030.

The number of the construction trades in March 2023 is 10,665. The number of employees in construction trades in January 2023 is 23,791 people. The number of legal entities in construction in December 2022 (active legal entities) is 18,730, and the number of employees in legal entities in construction in January 2023 is 108,197 persons. The above data represent the total capacity of the sector in terms of workforce given by the Bureau of Statistics.

The period from 2000 to 2008 for the construction industry in Croatia represents a phase of a great expansion, and the share of construction in GDP increased from 4 percent in 2000 to 7.2 percent in 2008. This is a period marked by the construction of large infrastructure projects in the field of road construction, (highways), but also a boom in the residential real estate market (apartment construction), which all together resulted in a strong growth in construction activity, which significantly pushed overall economic growth in the country. Unfortunately, these activities were mostly financed by (expensive) borrowing abroad. When the outbreak of the Great World Crisis in 2008 led to a sudden tightening in the possibilities of further financing construction expansion, a long six-year phase of contraction began. During that period, many construction companies in Croatia failed, and in 2014 the share of construction in GDP was again only 4.1 percent, similar to 2000. After six years of contraction, a gradual recovery is finally starting, and since 2018, it has been growing and further accelerating, so we can once again talk about the rise of the construction industry. Key indicators confirm that the growth of construction activity started in 2016 and continued in 2022 with an average growth of the construction works index of almost five percent. The value of new orders in the fourth quarter of 2022 compared to the same period in 2021 is higher by 35.2%. The value of orders from January to December 2022 is higher by 27.1% compared to the same period in 2021. The value of completed works with our own workers in the fourth quarter of 2022 compared to the same period in 2021 is higher by 20.7% January to December 2022 it is higher by 12.9% compared to the same period in 2021 [1].

These results are certainly related to the strong increase in demand from the private sector, which is based on the measure of subsidizing housing loans for young people, the growth of employment, the accumulated savings of citizens, and the growth of wages, which partially compensated for the growth of inflationary pressures. Furthermore, a relatively long period of low and almost negative interest rates on deposits and term savings on the one hand, and a tax system that does not tax property on the other, continuously stimulated citizens to invest excess available financial resources in real estate.

In addition, the growth of this sector is supported by the recovery of other parts of the economy in the post-pandemic period with an emphasis on tourism demand, Figure 32.

Data on issued construction permits suggest that similar trends will continue in the coming period. Construction activity in the next period will also be supported by the planned renovation of buildings damaged in the earthquake, infrastructure projects and investments in tourism.

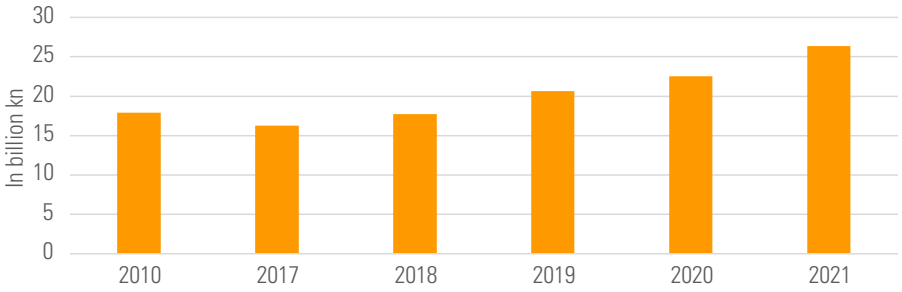

Figure 32 Economic value of the implemented work (Bureau of Statistics)

Regarding the increase in activity in the coming period, the reconstruction of buildings damaged in the earthquake will play an important role. In this context, it is interesting to look at the data of the Ministry of Physical Planning, Construction and State Assets on the reconstruction of the earthquake-affected areas of the city of Zagreb, Banovina and Sisak-Moslavina County, as well as the need for labor force presented in May 2023, as well as information on activities and values and the amount of construction work in the earthquake-affected area from the moment of the earthquake until the end of 2023.

Concrete figures as of May 19, 2023 show that a total of 933.3 million euros were spent for the reconstruction of public sector buildings and infrastructure for the Zagreb and Petrinja earthquakes. 683 projects were completed, including 275 projects for public buildings and 75 infrastructure projects. For the Zagreb earthquake, EUR 683.7 million was approved and EUR 582.8 million was spent (85% of the allocation), and for the Petrinja earthquake, EUR 319.2 million was approved and EUR 364 million was spent (108% of the allocation). There are currently 499 projects in the implementation phase, of which 299 relate to public buildings and 200 to infrastructure. The total value is 2.45 billion euros [2].

According to [2] of the total number of active construction sites, 1,010 refer to private buildings and houses:

- 650 non-structural renovations
- 62 structural renovations
- 147 replacement family houses
- 20 apartment buildings
- 131 prefabricated houses under construction for the expansion of homes for the elderly and infirm

The total amount spent so far for reconstruction amounts to 1.161 billion euros.

Furthermore, in the process of reviewing the documentation of the bids received, there are also 500 mobile homes for housing users of container accommodation, non-structural renovation for 201 family houses with energy renovation, construction renovation works of 2 apartment buildings in Sisak, construction works for 55 family houses in the area of Banovina, non-structural renovation works of 500 family houses and 50 structural family houses in the area of Banovina. The total estimated value of the mentioned works is EUR 42 million.

The construction of a total of 36 multi-apartment buildings worth 61.35 million euros is planned in the area of Banovina. The Decision of the Government of the Republic of Croatia for the construction of 11 multi-apartment buildings with about 200 apartments in the area of Sisak and Glina and the municipalities of Topusko, Jasenovac and Sunja with an investment value of 18.2 million euros with procurement in August 2023. Likewise, documentation is being prepared for the remaining 25 buildings with around 470 apartments worth 43.15 million euros and procurement in December 2023.

Regarding the self-renovation of private buildings and houses, by May 19, 2023, 3,679 buildings and houses worth 47.3 million euros have been renovated or are in progress. In addition, about 500 new requests for self-renewal were received. The Ministry's plan is to resolve requests for 300 buildings and houses undergoing self-renovation by the end of the year (50 structural renovations and 250 non-structural renovations).

In conclusion, by the end of 2023, the Ministry has the following plans:

1. Start of construction of 100 houses in the area of the Zagreb earthquake and 50 houses in the area of the Petrinja earthquake

- the average construction value is 150 thousand euros, a total of about 37.5 million euros

2. Structural reconstruction of 250 buildings and houses in the area of the Zagreb earthquake and 220 buildings and houses in the area of the Petrinja earthquake

- the average value of structural renovation of the buildings is 600 thousand euros, and the house is 30 thousand euros

3. Non-structural reconstruction of 350 buildings and houses in the area of the Zagreb earthquake and 400 buildings and houses in the area of the Petrinja earthquake

- the average value of non-structural renovation works is 10 thousand euros, and a total of 7.5 million euros

7.2. Workforce development

Related to the movement of the number of employees in the construction sector, in the phase of great expansion in 2000-2008 the number of employees increased from 110 to 160 thousand, or by almost 50 percent. In the phase that followed (2009-2014), 60 thousand construction jobs were lost in 6 years, that is, in 2014 there were fewer construction workers than at the beginning of the millennium.

With the accession of the Republic of Croatia to the EU, changes similar to those in the majority of new member states from the east of the EU took place, easier departure and employment of workers in other, as a rule, western member states. Taking into account this circumstance and the economic crisis that belatedly spread to the construction sector in the Republic of Croatia in the period 2010-2014, it is easy to determine that the stated circumstances (i.e. the impossibility of finding a job) encouraged a large number of construction workers to emigrate from the country when the borders were opened with Croatia's accession to the European Union.

Since 2015, the number of employees has been increasing again, and in 2020 there were 34% more construction workers than in 2014. However, due to previous developments, there has been a chronic shortage of workers, especially qualified workers, in this sector for a long time and which until now was somehow solved by importing labour.

At the same time, the number of employees in the construction sector continued to grow for the sixth consecutive year (Figure 33), and last year, for the first time, the number of employees in construction exceeded the level recorded before the outbreak of the global financial crisis in 2008, by 2,200 workers.

The growth of wages in the construction sector continued in 2022 with an increase of 9.6 percent in December, which is slightly above the average growth of 8.3 percent at the national level. The average net salary in construction amounted to 845 euros, which is almost 20 percent below the national average. According to the data of the Croatian Employment Service and the Croatian Association of Employers, in just three economic sectors in Croatia, tourism, catering and construction, Croatia currently lacks as many as 110 thousand workers.

According to the data of HUP - the Association of Employers in Construction, the following occupations are in short supply in this sector: mason, carpenter, rebar worker, concrete worker, welder, facade worker, fitter of building elements, operator of construction machinery, stonemason, crane operator, carpenter, construction worker, civil construction worker, pipeline fitter , painter and makeup artist, roofer, construction technician, construction manager, storekeeper on site, machine plasterer, plumber, electrician, heating and air conditioning installer, waterproofer, metal structure fitter, ceramic tile installer, sub-layer, insulator, tinsmith, locksmith, electrical fitter, electrician maintenance, machine and vehicle mechanic, mixer driver, auto concrete pump driver, truck driver, truck driver with trailer.

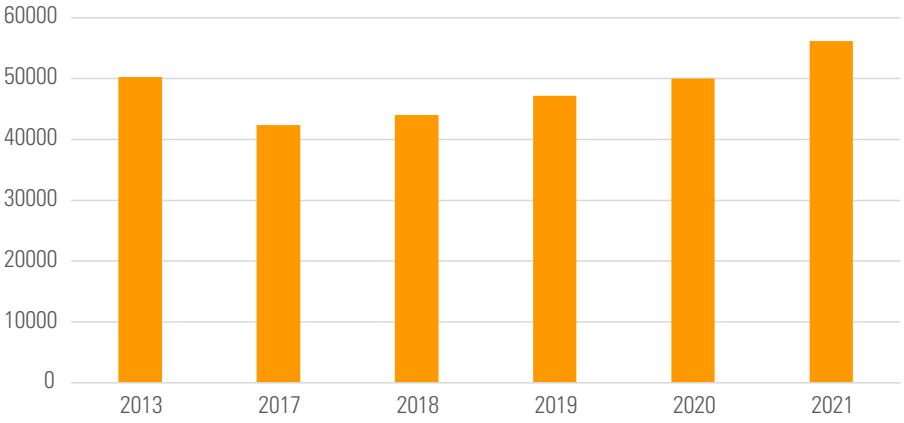

Figure 33 Average number of construction workers on construction sites

The lack of qualified workers on the domestic labour market in the construction sector has been an actual problem for several years, since the growth in that segment of the economy began (2014). The pandemic only made it more difficult and expensive to import labour and slowed down and changed the usual channels of arrival and departure of workers. At the same time, at the administrative level, the import of labour was facilitated in order to meet the rapidly growing need for workers, which could not be met in the short term - especially from the pool of domestic workers.

The construction sector has been struggling with the problem of labour shortage for years. The increase in quotas for the import of workers was not enough to solve this problem considering the higher wages offered to workers in some of the surrounding countries (Austria, Germany). The fact is that the largest number of residence and work permits in 2022 was issued precisely for this sector. More than 50,000 permits were issued in 2022. The changes that have occurred in this segment are manifested through the reduction of the workforce that comes from the traditional "pool" of workers from the region and surrounding countries, which are decreasing because they have also found jobs in member states further west than the Republic of Croatia. There are more and more workers from India, Nepal, the Philippines, Bangladesh and other distant countries.

However, the experiences of employers show that in terms of expertise and quality of construction work, workers from Croatia could reliably be replaced by workers from the region. Factors that influenced this relate to the relative similarities of edu-

cational systems, language and familiarity with similar construction techniques and materials used in construction.

Last year, a record number of residence and work permits for foreign workers was approved in Croatia, so 124,121 persons obtained or extended new permits on the Croatian labour market, which is 42,166 more permits than were issued and extended in 2021. According to data from the Ministry of the Interior (MUP), the largest number of residence and work permits in 2022 were issued to citizens of Bosnia and Herzegovina, Serbia, Nepal, North Macedonia and Kosovo.

As many as 36,783 citizens of Bosnia and Herzegovina, 19,176 citizens of Serbia, 12,222 Nepalese, 10,053 Macedonians and 8,979 citizens of Kosovo worked in Croatia. It is interesting to compare these statistics with those from 2021, when citizens of Bosnia and Herzegovina had 30,721 work permits, Serbs 13,579, citizens of Kosovo were third in terms of issued permits with 7,913 workers, Macedonians with 5,926 quarters, and citizens of Nepal fifth with 4,724 licenses [3].

The largest number of residence and work permits in 2022 was issued for construction 53,772, for tourism and hospitality 32,306 permits were issued, for industry 16,932, transport and communication sector 7,336 and for agriculture and fishing 2,957. **The most common residence and work permits issued for occupations are mason, waiter, carpenter, construction worker and cook.**

The lack of quality workforce, in addition to the quality, also affects the deadline for the execution of the works, i.e., more production workers are needed to complete the work in the given unit of time. As part of the analysis, an interview was also conducted with agencies that mediate the employment of foreign nationals, in order to obtain feedback on the real knowledge of imported construction workers. Although, in principle, every employment should be preceded by a professional pre-selection procedure, usually workers submit only the necessary certificates, and no pre-selection procedure is carried out. However, the experience with larger and more serious companies that employ a person from India is such that it takes approximately 4 months from approval to the arrival of the worker - they conduct remote worker testing. Most often, they do this for welders - a person presents knowledge in India, and an employee from the Republic of Croatia reviews the way of work online. By the way, workers from India are highly valued - as good masons, ceramicists, among other things, because a good part of the technology is similar. It is often the case that an Indian worker very quickly begins to supervise local workers on construction sites. Some of their technologies are different (for example, with Knauf or ceramics), but they very quickly accept domestic ways of installing materials and there are no problems. On the other hand, with workers from Nepal, of which there are definitely the most in the Republic of Croatia, it is a different story. As a rule, there is no pre-selection process for such workers in terms of determining knowledge/skills and qualifications. Most often, they come to the construction site and only on the construction site it is determined what they could and would be able to do. As a rule, their knowledge is deficient and insufficient. There is almost no knowledge of our work methods and materials.

Taking this into account**, it is easy to conclude that one of the weaker points of the Croatian construction sector is labour productivity.** Labour productivity is a concept used to measure worker efficiency and is calculated as the value of output produced by a worker in a unit of time, such as an hour. The concept can also be used at the national level to calculate a country's GDP (Gross Domestic Product). Productivity for a worker can be calculated using the following formula. Labour productivity = Value of produced goods and services / Input hour of work. The value of produced goods and services can be increased in several ways, in construction with an increase in capital equipment and technology - a key role is played by education, i.e. the level of knowledge of construction workers.

With a gross added value of 19 thousand euros per employee, only three EU countries record lower productivity. Although wages for construction workers have risen

in recent years, labour shortages will put pressure on their continued growth. However, the existing circumstances, i.e. the current capital equipment of construction companies in Croatia, technology, lack of qualified labour and construction costs, indicate that there is not much room for optimistic expectations of higher wage growth in the construction sector.

7.3. Skills Needs

7.3.1. Assessment of the required skilled workforce

The analysis of the number of workers required to achieve the 20-20-20 goals was made in the first Status quo analysis document [4] for workers specialized in the construction of zero-energy buildings as well as the renovation of existing ones, Table 45. The analysis only included workers in VET professions.

Table 45 Estimated number of workers required for 2020 in the first Status Quo analysis [4]

Type of works	Estimated number of workers required to achieve 20 - 20 - 20 objectives
Wall insulation	9.400
Roof insulation / replacement	5.700
Carpentry replacement	6.500
Biomass use	9.000
Solar energy	4.800
Wind energy	8.300
Total	45.000

In order to quantified labour workforce needed (VET workers) for reconstruction and building to achieve the goal until 2030, an additional analysis was made based on methodology from the first Status quo as follows. [4]

Based on the available information, it has been determined that for a complete change of external thermal insulation for an envelope area of 1000 m^2, it typically requires 8 trained workers and 5 working days. However, in order to obtain the surface of the envelope, the floor area was increased by 33%, and an assumed opening area of 30% was taken into consideration.

Regarding the renovation of roofs, it is assumed that for a residential building with an average roof area of 200 m^2, it requires 6 workers and 8 working days for completion. For non-residential buildings with an average roof area of 400 m^2, 10 workers and 10 working days are typically required. To estimate the number of floors, an average of 6 floors was taken for a residential building with two residential units per floor. The information regarding the renovation of residential and non-residential buildings, replacement of demolished residential buildings, and construction of new residential and non-residential buildings has been obtained from Table 12, which is expressed in the area of renovated buildings. The objective is to renovate 30.84 million m^2 of buildings by 2030.

In order to achieve the goals for energy efficiency in buildings until 2030, an estimated 22,000 VET workers will be needed per year, Table 46. Out of this number, approximately 9,400 workers will be involved in the renovation and construction of envelopes, while 6,000 workers will be focused on the insulation of roofs and the installation of windows and doors. The remaining 6,600 workers will be allocated for other related tasks.

Table 46 Estimated required number of EE workers for renovation/ construction per year (level 4 and 5 according to European qualification framework)

Type of work	Type of building	Total layout surface area	Envelope surface area	Opening surface area (window and doors)	Envelope surface area without openings	Roof surface area for a 30° slope	
		m^2	m^2	m^2	m^2	m^2	
Wall insulation	Renovation of residential buildings	20170000	26826100	6051000	20775100		
	Renovation of non-residential buildings	10670000	13871000	3201000	10670000		
	Replacement of demolished - residential	2400000	3192000	720000	2472000		
	New construction - residential	9600000	12480000	2880000	9600000		
	New construction - nonresidential	3270000	4251000	981000	3270000		
Insulation / replacement of roof	Renovation of residential buildings	2185083,33				7082862	
	Renovation of nonresidential buildings	10670000				34586385	
	Replacement of demolished - residential	260000				842780	
	New construction - residential	1040000				3371119	
	New construction - nonresidential	3270000				10599576	
Replacement of doors and windows	Renovation of residential buildings			6051000			
	Renovation of nonresidential buildings			3201000			
	Replacement of demolished - residential			720000			
	New construction - residential			2880000			
	New construction - nonresidential			981000			

	Planned annual building reconstruction per year until 2030	No of workers per 1000 m²	Reconstruction duration per unit (of wall, system of 1000 m²)	Total No of workers required for annual building reconstruction	Effective days per year	Average No of renovated units yearly per team	No of workers require for reconstruction/ renovation	Total number of workers needed per year
	m²/year	-	days	-	days	-	-	
	2596888	8	5	20775	220	5	4155	~9400
	1333750	8	5	10670	220	5	2134	
	309000	8	5	2472	220	5	494	
	1200000	8	5	9600	220	5	1920	
	408750	8	5	3270	220	5	654	
	885358	30	40	26561	220	31	845	~6000
	4323298	25	40	108082	220	31	3487	
	105347	30	40	3160	220	31	102	
	421390	30	40	12642	220	31	408	
	1324947	25	40	33124	220	31	1069	
	756375	42	1	2865	220		2865	~6600
	400125	42	1	1516	220		1516	
	90000	42	1	341	220		341	
	360000	42	1	1364	220		1364	
	122625	42	1	464	220		464	

The estimation of RES VET workers was conducted using Table 33, which provides current and expected data on the installed power and energy production for each technology of renewable energy sources employed to achieve nZEB. To determine the number of workers required to meet RES goals by 2030, job estimation values per technology (job-years/GWh) was used where values are described in detail by authors Wei et al. [5] energy efficiency (EE. The required workforce numbers per RES technology until 2030 are presented in Table 47. Methodology for estimation of RES workers is the same as in the document Status quo analysis of the building sector in Croatia and skills of construction workers in the field of energy efficiency and renewable sources of energy [65].

Table 47 Estimated number of RES workers (level 4 and 5 according to European qualification framework)

RES technology	Installed power until 2022 MW)	Expected installed capacity in 2030 (MW)	Energy production capacity in 2022 (GWh)	Expected energy production capacity in 2030 (GWh)	Average energy production (MWh per installed MW)	Average working life of equipment (years)	Average annual employment, workforce GWh	Required number of workers for RES per year
Solar thermal systems for heating	209,15	317,01	259,35	393,09	1240	25	0,23	150
Biomass boilers and furnaces for heating all types of buildings	7242,26	7591,81	13036,07	13665,25	1500	30	0,21	600
Shallow and deep heat pumps for heating and cooling	27,96	70,08	174,45	437,29	5000	25	0,25	250
Above-ground heat pumps for heating and cooling	103,81	179,85	647,79	1122,3	5000	25	0,25	430
Integrated photovoltaic power plants in buildings (electricity)	133,37	440,42	153,38	506,49	1150	25	0,87	1100

To estimate the number of engineers needed for the renovation and construction of buildings, two separate calculations were made: one for those involved in designing and one for those involved in construction. For designing purposes, assumptions were made based on industry contacts and design offices. It is assumed that the design of a building would require one civil engineer, one architect, one mechanical engineer, and one electrical engineer (1 team). On the other hand, for the construction of a building, one civil engineer would suffice. Regarding the dynamics of the design process, it is assumed that each team can renovate or construct an average of 10 residential and non-residential units per year. In terms of construction, the assumed dynamic is 1.5 buildings per year.

Based on the analysis, it is evident that a total of 2,500 engineers are required for the design phase, which translates to approximately 625 engineers per profession, Table 48. Additionally, for the renovation and construction phase, 3,300 construction engineers are needed, Table 49, or 825 engineers by profession. A total of 1,450 engineers are needed for design and construction purposes.

Table 48 Estimated required number of engineers for renovation/ construction per year (design process) (level 6 and 7 according to European qualification framework)

Type of work	Type of building	Total lay-out sur-face area	Average surface area	Average number of build-ing	Number of engineers needed per building (1 team)	Average No of renovat-ed units yearly per team	Required number of teams for re-construction / renovation / new con-struction	Required number of engineers for reconstruc-tion / reno-vation / new construction	Total number of engineers needed per year
	m²	m²/year	m²	-	-	-		-	
Renovation of residen-tial buildings	20170000	2521250	955	2640	4	8	330	1320	
Renovation of non-res-idential buildings	10670000	1333750	2642	505	4	8	63	252	
Replace-ment of demolished - residential	2400000	300000	955	314	4	8	39	157	~2500
New con-struction - residential	9600000	1200000	955	1257	4	8	157	628	
New con-struction – non-resi-dential	3270000	408750	2642	155	4	8	19	77	

Table 49 Estimated required number of engineers for renovation/ construction per year (construction process) (level 6 and 7 according to European qualification framework)

Type of work	Type of building	Total lay-out sur-face area	Average surface area	Average number of build-ings	Number of engineers needed per building (1 team)	Average No of renovat-ed units yearly per team	Required number of teams for re-construction / renovation / new con-struction	Required number of engineers for reconstruction / renovation / new construc-tion	Total number of engineers needed per year
	m²	m²/year	m²	-	-	-		-	
Renovation of residen-tial buildings	20170000	2521250	955	2640	1	1,5	1760	1760	
Renovation of non-res-idential buildings	10670000	1333750	2642	505	1	1,5	337	337	
Replace-ment of demolished - residential	2400000	300000	955	314	1	1,5	209	209	~3300
New con-struction - residential	9600000	1200000	955	1257	1	1,5	838	838	
New con-struction – non-resi-dential	3270000	408750	2642	155	1	1,5	103	103	

Total number of workforce needed per European qualification framework is given in Table 50.

Table 50 Estimated workforce needed until 2030

	Type of works	Estimated workforce needed	European qualification framework level
VET workers (blue collar workers)	Wall insulation	9.400	Level 4. and 5.
	Roof insulation/ replacement	6.000	
	Carpentry replacement	6.600	
	Solar thermal systems for heating	150	
	Biomass boilers and furnaces for heating all types of buildings	600	
	Shallow and deep heat pumps for heating and cooling	250	
	Above-ground heat pumps for heating and cooling	430	
	Integrated photovoltaic power plants in buildings (electricity)	1100	
	VET total	**24.530**	
Engineers (white collar workers)	Engineers for renovation/ construction (design process)	2.500	Level 6. and 7.
	Engineers for renovation/ construction (construction process)	3.300	
	High institution total	5.800	
	TOTAL	30.330	

A comprehensive analysis was conducted on the transition of the labor force from the education system to the job market over a span of four years, as presented in Table 51. The data for vocational education and training (VET) were obtained from Chapter 5, which covers the existing provisions in the field of Education and Training. Among the requested data collected through surveys conducted in VET schools, the number of students who successfully completed their education (Table 35) was included. The findings from this analysis are summarized in Table 51 for the specified four-year period. Notably, there is a slight increase in the number of students who completed their education in three-year vocational professions during the school year 2021/2022, compared to previous years. However, for four-year vocational professions, there is a slight decrease in the number of students. Overall, there is a discernible trend of an increasing number of students successfully completing their VET education on a yearly basis. While the Croatian Bureau of Statistics consistently provides data on students who have successfully graduated or completed their studies in the technical field at universities (as indicated in Table 35), the evaluation of the labor force in high-level education primarily relies on enrollment quotas (as depicted in Table 38 and Figure 11).

This approach was chosen as it specifically encompasses the area of interest for this study, despite the fact that the actual number of students who complete their high-level education is significantly lower in reality. For example, the enrolment quota for the Faculty of Civil Engineering at the University of Zagreb is 240, while the number of master's students who graduate from the Faculty of Civil Engineering is much lower (from 20% for the year 2018/2019 to 45% for 2021/2022. The same situation can be found at the Faculty of Architecture University of Zagreb: the number of students who complete the Master's level is lower from 28% for the year 2020/2021 to 46% for 2021/2022 compared to the enrollment quota (167 students). The official data on the number of students who complete the master's

level from the Faculty of Civil Engineering Faculty of Architecture University of Zagreb were taken and compared to enrolmment quotas (240 for the Faculty of Civil Engineering and 167 for the Faculty of Architecture respectively). It was found that on average there are 37% fewer students who complete the master's level. This percentage was taken into account and in Table 25 the total number of students was reduced by 37% in order to get the correct data on force entering the market after finishing high level of education (level 7).

Table 51 Labour force after education and entering the labor market in the 4-year period

		2018/2019	2019/2020	2020/2021	2021/2022
	Civil engineering and architecture	131	163	186	230
Level 4.1.	Mechanical and Electrical Engineering	387	406	448	567
	Total	518	569	634	797
	Civil engineering and architecture	603	549	556	583
Level 4.2.	Mechanical and Electrical Engineering	337	297	294	269
	Total	940	846	850	852
	VET total	**1458**	**1415**	**1484**	**1649**
	Civil engineering and architecture	2165	2160	2160	2110
	Mechanical Engineering	1569	1845	1840	1776
Level 7	Electrical engineering	2277	2292	2392	2392
	Total (High institution)	6011	6297	6392	6278
	Total (High institution) - decresed by 37%	2224	2330	2365	2323
	TOTAL	**3682**	**3745**	**3849**	**3972**

A careful comparison between Table 50 and Table 51 reveals a clear and concerning pattern - there is a notable shortage of skilled manpower necessary to achieve the ambitious energy efficiency goals set for buildings in Croatia until 2030.

7.3.2. Skills needs - questionnaires among craftsmen and entrepreneurs

In order to establish the knowledge of workers and craftsmen who perform construction works, and so that, based on the current situation, gaps and key needs for further training could be determined, questionnaires were maid with questions covering different areas, but generally consisting of two types of questions - general and detailed. The questionnaires that were delivered to the craftsmen, i.e., their owners and employees, took into account the Status Quo analysis that was carried out in 2012/2013 (exactly 10 years ago) and certain questions were repeated, in order to be able to analyze the changes in the observed 10-year cycle and progress in attitudes, and knowledge of energy-efficient technologies.

General questions, were composed in such a way as to determine the structure of trades that perform construction work today with all indicators (size, types of work, number of workers, etc.), but also to determine the level of knowledge and motivation of tradesmen and directors and their employees about energy efficiency and new technologies and trends in the construction

More detailed questions about new technologies and their application in the context of energy efficiency in buildings, such as the level of knowledge of energy-efficient technologies, the proportion of work in everyday business that relates to the direct installation of energy-efficient technologies or aims to increase energy efficiency, the types of energy-efficient technologies that are used in everyday business. Further-

more, we examined the relationship towards the use of energy-efficient technologies and digitalization. We also wanted to get an insight from the respondents into the attitudes related to the education of workers, the preferred modalities of education, and the views on optimal policies for the education of workers. The questionnaires also focus on the attitudes of craftsmen about the lack of qualified workers, the employment of foreign workers. In conclusion, the craftsmen gave a significant insight into the needs among their employees regarding the types of education and the necessary knowledge about certain technologies.

Questionnaires were delivered to craftsmen directly with a link to google forms. Likewise, in order to increase the visibility of the project, but also to obtain direct information from craftsmen and workers, several visits will be held in the form of educational round tables.

The questionnaires were answered by workers and managers from the following professions: work on the outer envelope, electrical installations, gas, heating, water and air conditioning installations, dry construction, roofers/carpenters, carpenters, glass workers, renewable sources (photovoltaic, cogeneration). The questions for each of the representative groups of craftsmen will try to gain insight into the needs for capacities, knowledge and skills of workers in each of the mentioned sectors, which will serve as a basis for the approximation of skills at the sector level.

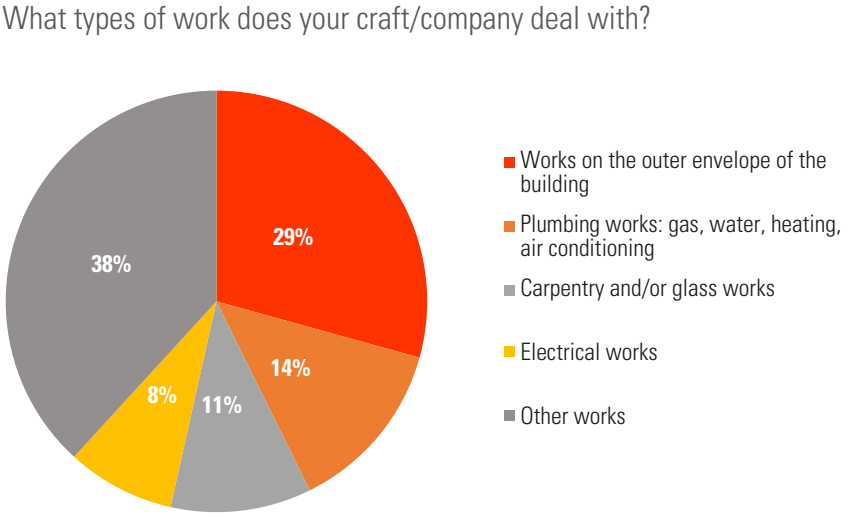

Figure 34 Overview of responses – company's types of work

Figure 34 shows us the structure of jobs that the examined craftsmen and entrepreneurs deal with. The largest share of them work on the outer envelope of the building (29%), followed by installation work (14%) and carpentry and/or glass work (11%). Apart from them, the percentage of those who perform electrical installation work is not negligible (8%). In addition to the jobs that are most often performed among the respondents, as many as 38% of the respondents are engaged in some other type of work, such as: renewable sources (photovoltaic), dry construction, finishing works, interior works, masonry works, ceramic works, roofing...

How many years has your construction trade/company been in business?

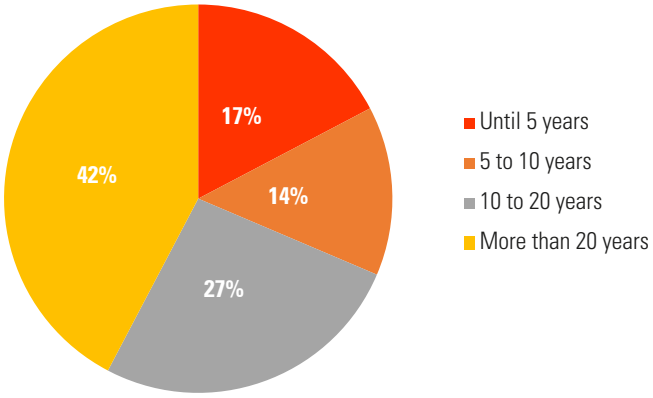

Figure 35 Overview of responses – Company's' years of experience

And this research confirms past experiences that the most inclined to communicate with organizations that represent employers (like HOK) are those craftsmen who have longer work experience and whose crafts have been on the market for more than 5 years. Moreover, Figure 35 shows that by far the largest group in the answers are those trades that have been on the market for 20 years or more, which indicates a strong connection between the inclination to education and the longevity of the trades. The longevity of construction trades shows their strength and importance for the entire construction sector of the Republic of Croatia.

How many workers do you employ?

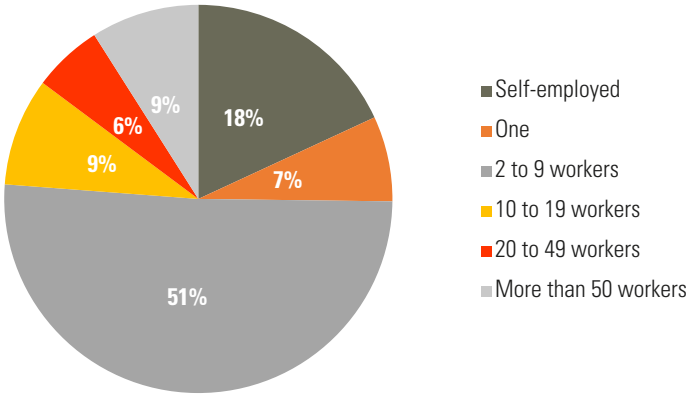

Figure 36 Overview of responses – number of workers per company

Given that the largest number of answers comes from construction trades, it is not surprising that the largest number of respondents employ from 2 to 9 workers (51%). More than 20, but less than 50 workers employ 18% of the respondents. Figure 36 also shows the remaining trades/enterprises by number of employees in equal proportions.

How familiar are you with energy efficient systems and technologies?

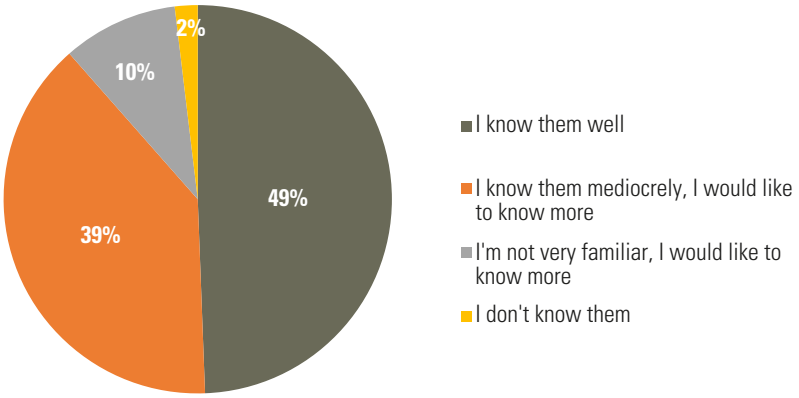

Figure 37 Overview of responses – familiarity with energy efficiency technologies

Figure 37 gives us information on the level of familiarity of craftsmen and entrepreneurs with energy-efficient systems and technologies. Almost half of the respondents believe that they are well acquainted with energy-efficient systems and technologies, and 39% of them have an average knowledge of such systems and technologies and would like to know more. Only 12% of the responses indicate that craftsmen and entrepreneurs are poorly informed or do not know energy-efficient systems and technologies at all.

Do you use energy efficient systems and technologies?

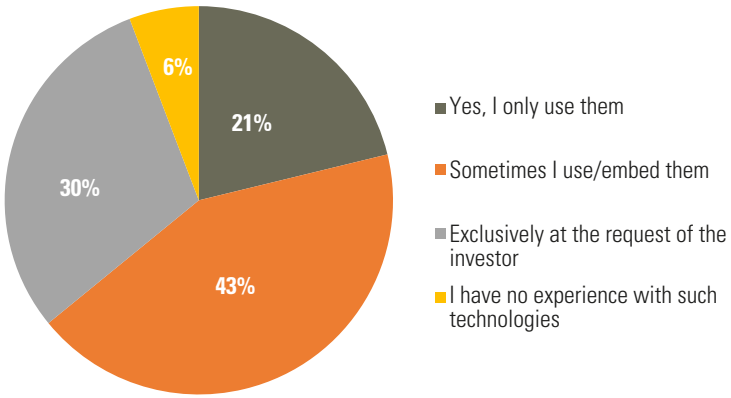

Figure 38 Overview of responses – use of EE systems and technologies in business

A negligible number of respondents (6%) have no experience with energy-efficient systems and technologies, Figure 38. Even 43% sometimes use/install such systems, and 30% exclusively at the request of investors. The data on 21% of respondents who exclusively use energy-efficient systems and technologies shows us an increase over the years, which we will explain in more detail in the comparative graphs below.

Together with the data obtained as part of the Build up skills project, individual data obtained from craftsmen and entrepreneurs can be compared and further analyzed. Everything is aimed at getting a clearer picture of construction workers' familiarity with energy-efficient systems and technologies, as well as the use of such systems and technologies over time, Figure 39.

Familiarity and use of EE technology

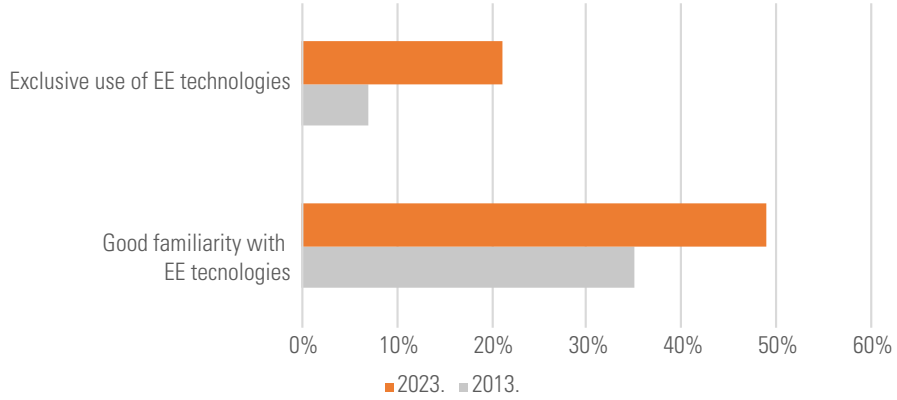

Figure 39 Comparison of data - awareness and use of EE technologies in 2013 and 2023

By comparing the data obtained in 2013 and 2023, we obtain information about the better familiarity of craftsmen and entrepreneurs from the construction sector with energy-efficient systems and technologies Figure 39. 10 years ago, the share of those who were well acquainted with energy-efficient systems and technologies was 35%, while today it has reached 49%. The reason for such a thing is certainly the desire of the end user to use systems that bring lower energy consumption, and thus lower costs. In addition, it is necessary to classify everything with the aspiration to contribute to mitigating climate change.

Furthermore, it is clear that there has been an increase in the number of craftsmen and entrepreneurs who use only energy-efficient systems and technologies in their business. In 2023, the share of those who exclusively use energy-efficient systems and technologies amounts to 21%, while 10 years before that it was only 7%.

It is extremely important to encourage entrepreneurs to use energy-efficient systems and technologies in construction, so it is interesting to observe their thoughts on the preferred ways of encouraging the use of such systems.

Which energy-efficient systems and technologies do you now and/or use in your business? (it's possible to choose more than one answer)

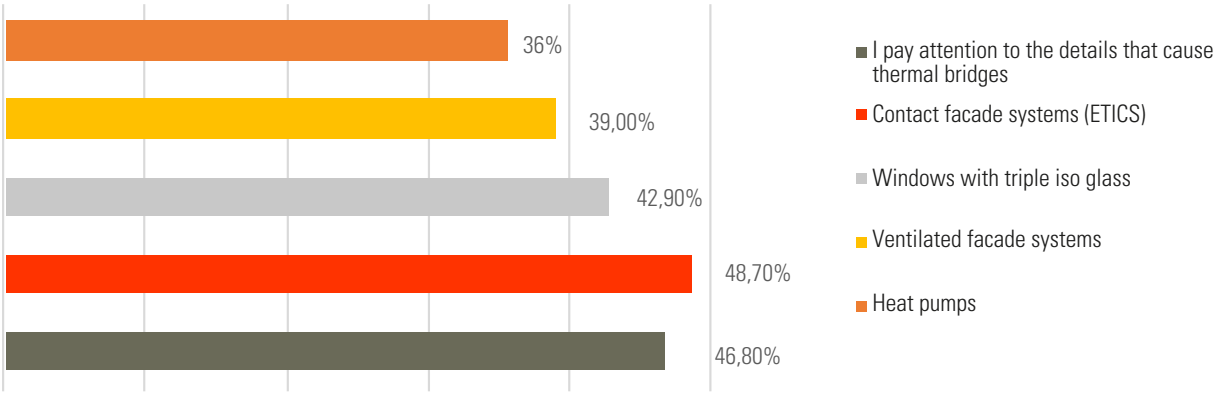

Figure 40 Overview of answers - knowledge and use of EE technologies and systems

Figure 40 shows us which energy-efficient systems and technologies entrepreneurs and craftsmen know and/or use in their business, while they could choose several offered options. Most of them know or use contact facade systems (ETICS), but they also focus a lot of attention on the details that cause thermal bridges (46.80%). Among the most common technologies and systems they use and/or know about are triple-glazed windows, ventilated facade systems, and heat pumps.

From the entrepreneur's perspective, this would encourage greater use of energy-efficient systems and technologies?

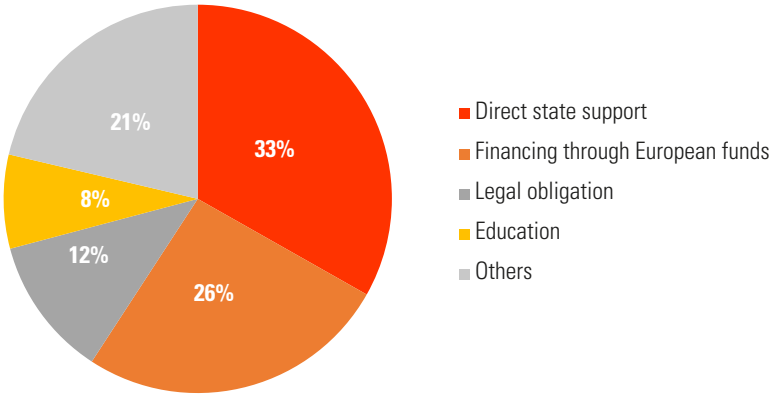

Figure 41 Overview of responses – encouraging the use of technologies

Figure 41 shows how entrepreneurs believe that the best way to encourage the use of energy-efficient systems is through direct government subsidies (33%), followed by financing from European funds (26%). Some of them believe that such a thing should be regulated by the state through the imposition of legal obligations (12%), but also through staff training (8%). The rest of the responses received refer to stricter construction controls, greater activity of manufacturers in promoting such systems and products, and reducing the prices of new technologies.

Encouraging the use of EE technologies

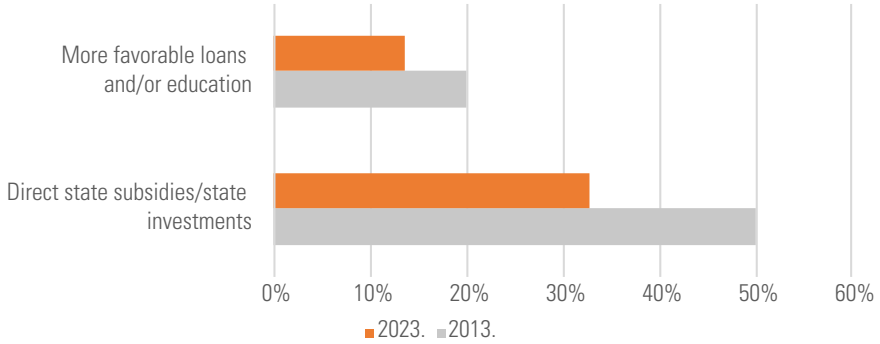

Figure 42 Comparison of data - encouraging the use of technologies in 2013 and 2023

Comparing the data obtained in 2013 and 2023 (Figure 42), there is a decrease in the percentage of those who believe that the use of EE technology can be obtained through more favorable loans or education, that is, through direct support from the state. The above data should be viewed through the prism of the Republic of Croatia's entry into the European Union, therefore today as many as 26% of respondents believe that encouraging the use of EE technology is most optimal through European funds, because 10 years ago it was not possible.

Are you considering additional education to obtain certificates in energy efficiency and sustainable green construction?

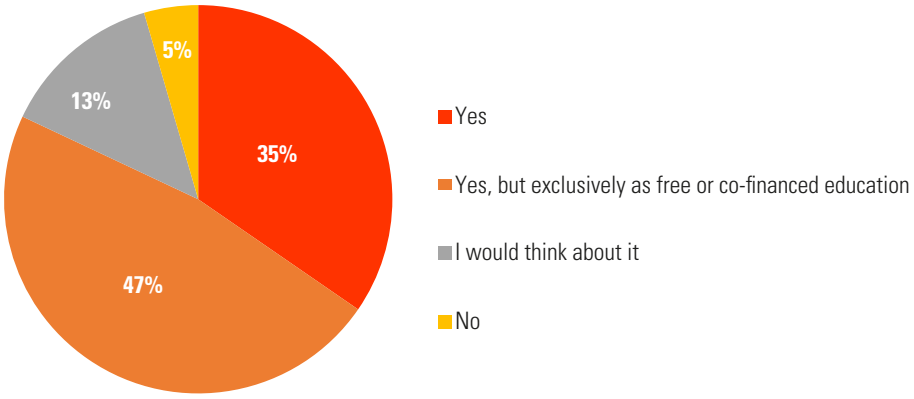

Figure 43 Overview of responses – additional education

The readiness for additional education of entrepreneurs in the sense of obtaining a certificate of energy efficiency and sustainable green construction is shown in Figure 43. Almost half of respondents are ready to receive additional education, but only on the condition that the education would be free or co-financed, while 35% of respondents are ready to receive additional education educate without any conditions. Only a small proportion of the answers includes those who would consider or would not get additional education at all.

Additional education - EE certificates

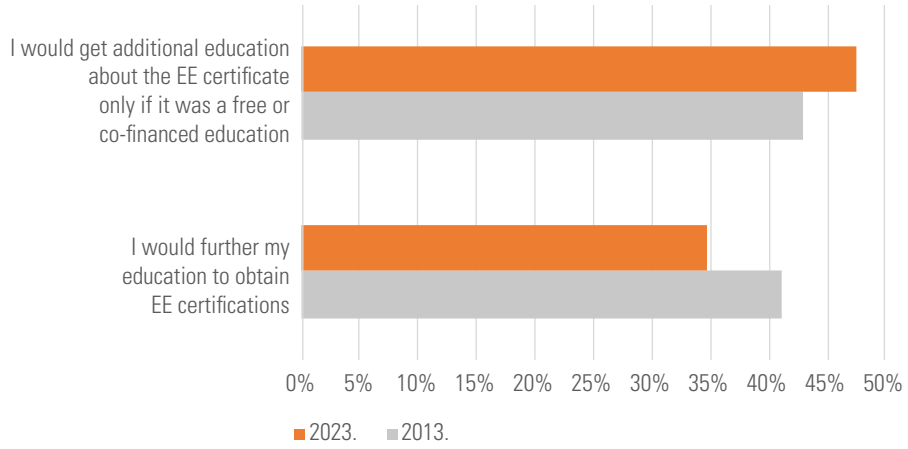

Figure 44 Comparison of data - Readiness for additional education in 2013 and 2023.

Data on entrepreneurs' readiness for additional education did not change significantly over 10 years. Figure 44. However, there was a decrease in those who would receive additional education today (35%), compared to 2013 (41%). This information very likely results in the fact that some of the entrepreneurs have been additionally educated in the meantime, that is, they have acquired the necessary certificates. Nevertheless, in 2023, more respondents (47%) are ready to receive additional education, provided that it is free or co-financed education, than was the case in 2013 (43%).

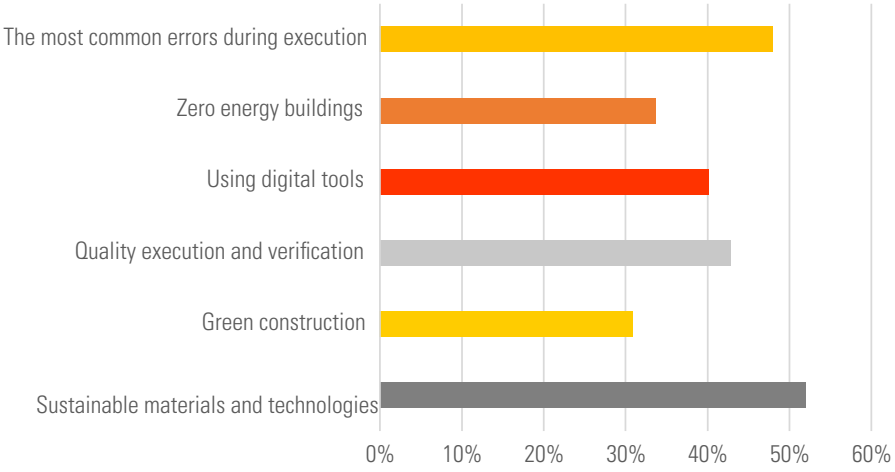

Figure 45 Overview of responses - Education topics for craftsmen and entrepreneurs

In addition to readiness for additional education, we also wanted to find out through the questionnaires which targeted educations in the context of energy efficiency would be of most interest to craftsmen and entrepreneurs, with the possibility of choosing more than one, Figure 45. **Sustainable materials and technologies are of most interest to the real sector, followed by the most common errors during execution, quality execution and execution quality control, use of digital tools, energy efficiency and renewable energy sources, almost zero energy buildings and other types of education.**

Is there a lack of qualified workers in your trade/company?

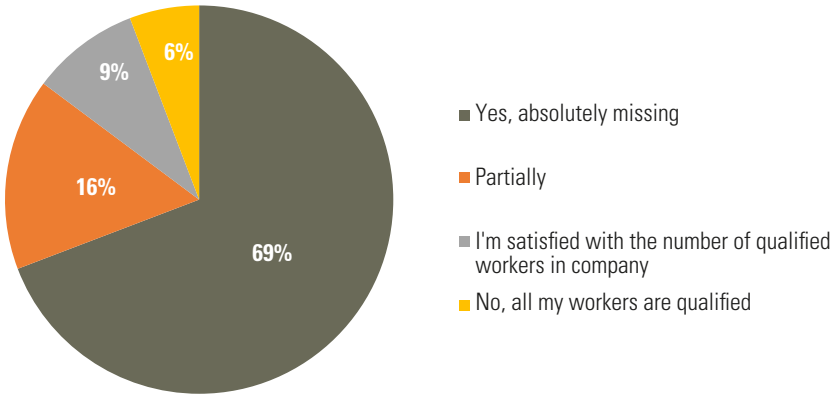

Figure 46 Overview of responses – Lack of qualified workers

More than two-thirds of entrepreneurs and craftsmen believe that there is an absolute lack of qualified workers in their businesses. Figure 46 also shows that 16% of respondents claim that there is only a partial lack of qualified workers in their company. Only 15% of entrepreneurs are satisfied with the number of qualified workers or employ fully qualified workers.

What kinds of difficulties do you face when looking for workers?

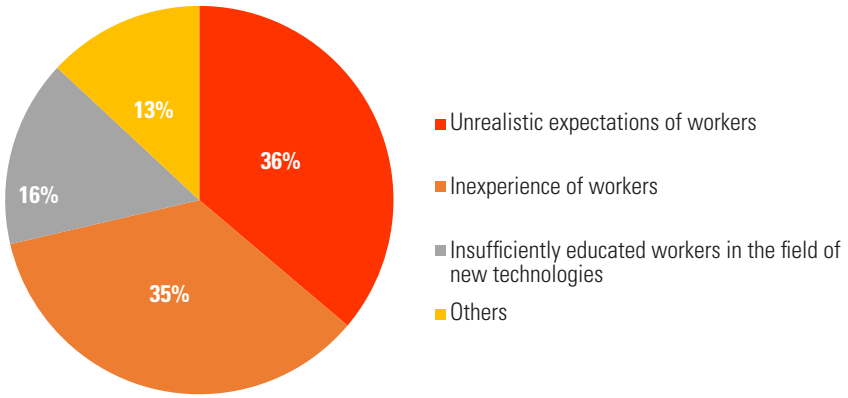

Figure 47 Overview of responses - Difficulties in finding workers

The previously presented data on the lack of labor in the construction sector and the increase in the number of work permits have a link with the information from Figure 47. 36% of respondents believe that workers have unrealistic expectations, and 35% of them have a problem with the lack of experience of workers. In addition, there are not enough educated workers in the field of new technologies (16%). Of the remaining responses, employers state that there simply aren't enough workers, and the main reason is the departure of young and promising people abroad.

Have you decided to hire foreign nationals due to the lack of manpower?

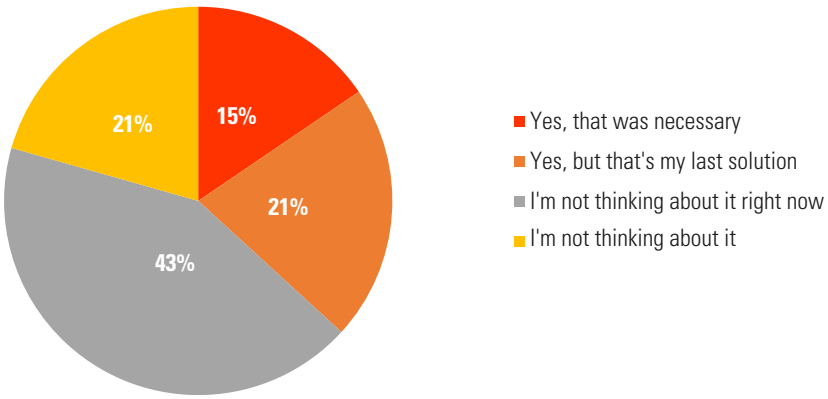

Figure 48 Overview of responses - employment of foreign workers

Data on more than 50,000 issued work permits for foreigners in the construction sector in 2022 clearly show the necessity of importing labor. However, Figure 48 shows that 21% of our respondents have not decided to employ foreign nationals and are not thinking about it at all, and that 43% of respondents are not currently thinking about such a solution. A fifth of the respondents decided to employ foreign nationals, stressing that this was their last resort. And finally, 15% of employers have employed foreign nationals and consider this option necessary for the continuation of business.

Is it possible to change the trend of lack of qualified workers?

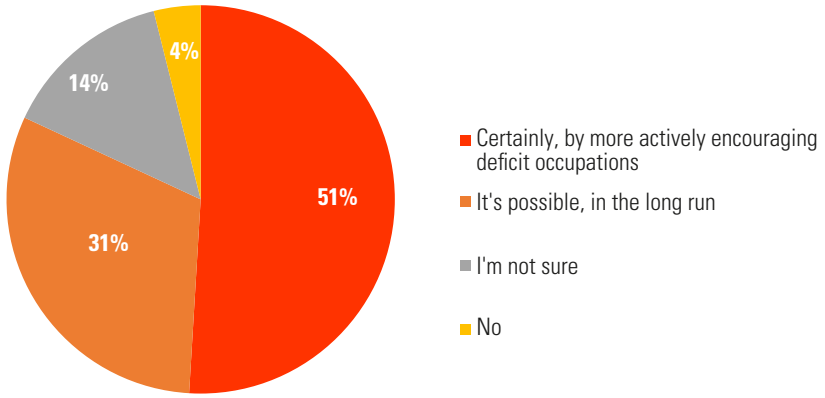

Figure 49 Overview of responses - the possibility of changing the trend of the lack of qualified workers

Figure 49 shows that more than half of the respondents (51%) believe that it is possible to change the trend of the lack of qualified workers by more actively encouraging deficit occupations, while 31% believe that it is possible to change the trend, but in the long term. A total of 18% of respondents are not sure about the possibility of changing the negative trend or believe that such a trend cannot be changed at all.

Have to change the trend of shortage of qualified construction workers?

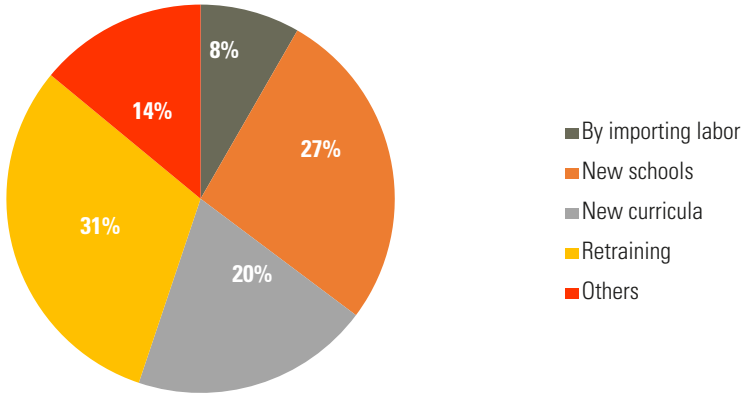

Figure 50 Overview of responses - ways to change the trend of lack of qualified workers

In correlation with the data shown in Figure 48, where 64% of respondents claim that they have not employed foreign nationals and are not considering this option at all or at the moment, Figure 50. shows that only 8% of respondents believe that the trend of the lack of qualified workers can be changed by importing labor. The majority claims that the trend can be changed with retraining, new schools and/or new curricula. Other answers refer to salary increases, a combination of the proposed options, but also by abolishing the encouragement of self-employment.

What is the reason for the insufficient number of qualified workers in construction sector? (it's possible to choose more than one answer)

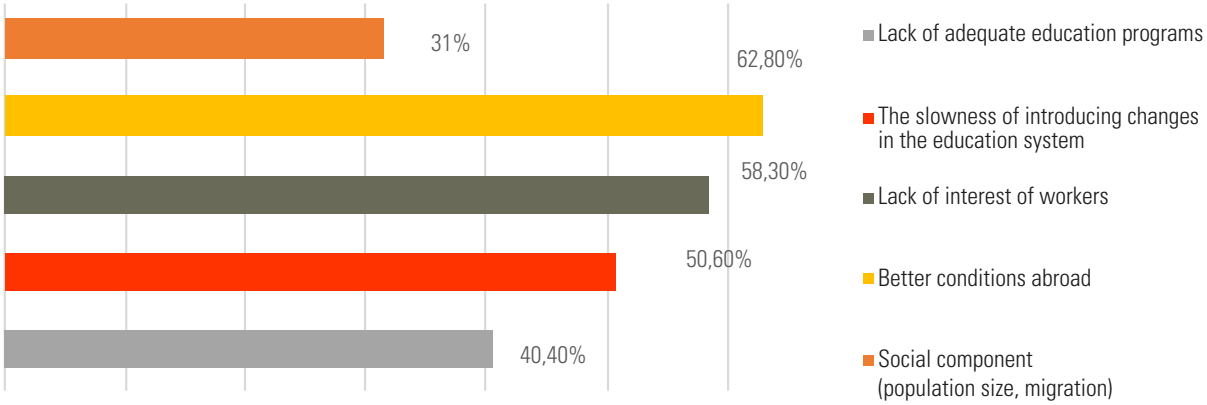

Figure 51 Overview of responses - reasons for the insufficient number of qualified workers

The largest number of respondents believe that the most frequent reason for the lack of qualified workers is of an economic nature, i.e. better conditions abroad, Figure 51. A large proportion claims that the reason is the lack of interest of the workers, while half of the respondents choose the slowness of introducing changes in the education system. The lack of adequate education programs and the social component of the Republic of Croatia are also among the most common reasons cited by entrepreneurs as a consequence of the lack of qualified workers in the construction sector. In addition to the above, the survey also mentions as reasons: economic (un) opportunities, poor representation of such jobs in the media and unattractiveness of jobs.

How important is adaptation to digitalization requirements in the construction industry?

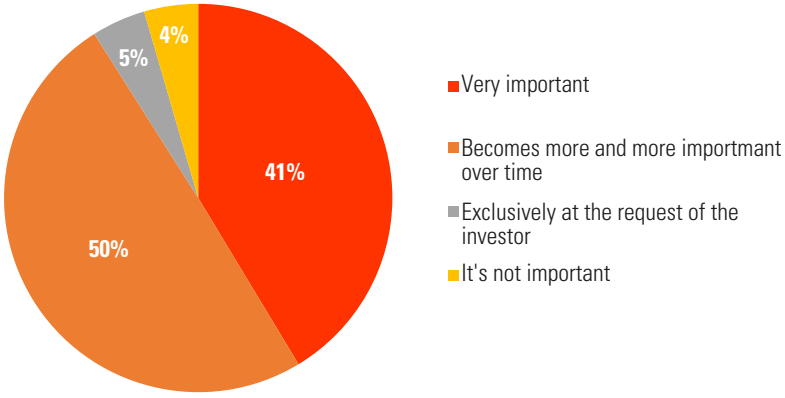

Figure 52 Overview of responses - the importance of digitalization of the construction sector

Digitalization of business speeds up processes and reduces costs, therefore it is necessary to gradually digitize the construction sector as well, Figure 52. For this reason, we asked craftsmen and entrepreneurs how important is adaptation to digitalization requirements in the construction industry? The answers show us that the real sector

is absolutely aware of the importance of digitalization, as half of the respondents believe that digitalization is becoming more and more important over time, and 41% of craftsmen and entrepreneurs believe that adapting to the demands of digitalization is very important. Less than 10% of the surveyed opinions are that adaptation to these requirements is important only at the request of investors and/or it is not important to them at all.

To what extent are you familiar with the development and digitazation of the construction sector?

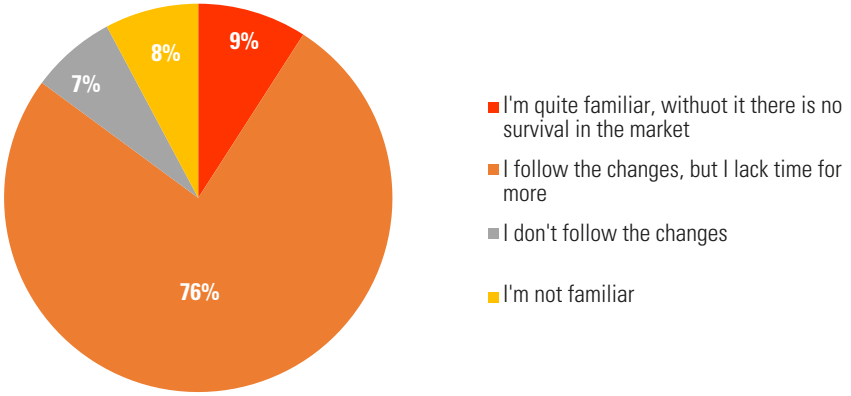

Figure 53 Overview of responses -Familiarity with digitalization of the construction sector

More than two-thirds of the respondents follow the changes brought by the digitalization of the construction sector, but they lack time for more than that, Figure 53. On the other hand, 9% of the respondents are quite familiar with the digitalization of the sector and believe that without it there is no survival on the market. A small proportion of respondents (15%) do not follow the changes and/or are not aware of them at all.

Do you think that digitization will bring positive effects it the business of the construction sector?

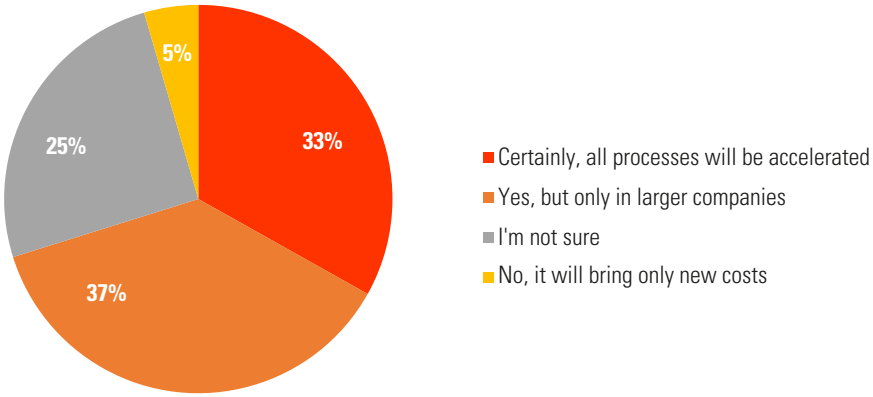

Figure 54 Overview of responses - Consequences of digitalization of the sector

33% of respondents believe that digitalization of the construction sector will bring positive changes in business and, as a result, all processes will speed up. Figure 54 also shows us that 37% of the respondents believe that there will be positive changes in business as a result of digitalization, but only in larger companies. Likewise, 25% of those surveyed are not sure of positive developments, and 5% of them claim that there will be no positive developments, but only additional business costs.

In the *Chapter 5* a deep analysis of currently available courses was done where the content of individual subjects and learning outcomes (if defined) are overviewed and grouped to specific skills to which the current high education system already addresses, Table 39. In all three areas (civil engineering architecture, and mechanical engineering) most courses are relevant to energy efficiency and renewable energy in buildings and therefore cover skills for implementation of energy efficiency and renewable energy measures in buildings. By additional analysis, it should be emphasized that by comparing the statistical data of student attendance of the identified courses (given in Table 41) in a 4-year period and the quota of students who enroll in the higher institutions, an average of 18% of students take courses related to energy efficiency (EE), renewable sources (RES), green construction, sustainability etc. in the construction and architecture sector, 8% in the engineering sector, and 13% in the electrical engineering sector. This means that very few students enter the labor market with knowledge and skills related to EE and RES. Even the analysis under BIMzeED project that was gathered on a sample of the workforce working in the field of EE and BIM for 10 years (Figure 17, Figure 18, Figure 19) showed the low self-assessment grades on knowledge and understanding of EE and BIM.

Existing civil engineering and architecture studies showed a lack of courses that deal with the topics of building renovation toward nZEB and ZEBs (especially of historical, heritage buildings), using BIM in renovation and implementation of EE and RES measures in the new and old buildings, using life cycle assessment with focus on Global Warming Potential and circulatory and resource efficiency as a part of project design and during construction/ renovation. Mechanical engineering course showed the lack of courses dealing with RES in renovation (including heritage buildings), using BIM, implementing sustainability quantification and measures and RES management system and control while electrical engineering course lacks programs in BIM implementation, upgrading the smartness of buildings for greater energy performance (in old and new buildings), sustainability quantification and Sensors, building controls and building management system. Table 52 shows emerging skills and qualifications needed for EQL 7. The skills dealing with implementation of energy efficiency and renewable energy measures in buildings showed an increase. High safety standards and regulation should be covered for all white-collar workers.

Table 52 Emerging skills needed for EQL 7

Civil engineering and architecture	Mechanical engineering	Electrical engineering
Implementation of energy efficiency and renewable energy measures in buildings		
Digitalization (BIM)		
Safety		
Sustainability quantification (via the assessment of Global Warming Potential), circular construction and resource efficiency, and leveraging the Level(s) framework		
Bridging the gap towards Zero Emission Buildings (ZEBs)		
Building deep renovation (including heritage buildings)	Implementation of RES in deep renovation and heritage buildings	Upgrading the smartness of buildings for greater energy performance (in old and new buildings)
Building management system	RES management system and control	Sensors, building controls and building management system

7.4. Qualification needs

When comparing the estimated number of workers needed for the renovation and construction of NZEB buildings per year, it is evident that a minimum of 3000 educated EE VET workers are required assuming that by 2030 we have trained all 22,000 workers. The goal of training 22,000 educated workers for the renovation

and construction of NZEB buildings by 2030 requires a significant amount of effort and resources. However, achieving such a goal in such a short timeframe may be challenging.

The data from the questionnaire filled out by craftsmen and entrepreneurs by the type of work they perform on construction sites were analyzed, in order to obtain more precise information about the knowledge and skills of the aforementioned workers, comparing them with the assessments of the required workers in terms of energy-efficient technologies that are needed to achieve the goals until 2030.

The analysis estimated that 9,400 professional workers are needed annually to achieve energy efficiency goals in the building industry in the segment of wall insulation. Out of the total number of responses, 28% of craftsmen and entrepreneurs declared that they perform work on the outer envelope of the building. By far the largest percentage of surveyed tradesmen and entrepreneurs who perform work on the outer envelope of the building claim to be well acquainted with energy-efficient systems and technologies (60%), followed by those who are moderately familiar and would like to know more (36%), while only 4% of them consider they are poorly acquainted with energy-efficient systems and would like to know more. It is also interesting to observe their thoughts on what they consider especially important for increasing energy efficiency, where all those who perform work on the outer envelope of the building consider that high-quality thermal insulation is particularly important for increasing the energy efficiency of buildings.

We based the assessment of the number of necessary additional educational programs and qualification needs for workers on the outer envelope of the building on the answers of respondents who deal with this type of work, comparing them with the estimated number of workers needed to achieve the energy goals by 2030. Additional education and qualifications are needed for 40% of the estimated number of workers involved in the renovation and construction of the envelopes, that is, 3,760 workers need to be further educated and trained in order to contribute their knowledge and skills to efforts to achieve energy goals by 2030.

On the other hand, for roof insulation, i.e. roofing replacement, it was estimated that 6,000 VET workers will be needed for this type of work in the context of achieving energy efficiency goals in the building industry by 2030. Among the respondents, 5% perform roof replacement and/or roof insulation work. All of them have many years of experience in this type of work (more than 10 years). Of the above, 57% of the responses tell us that they are moderately familiar with energy-efficient systems and technologies and would like to know more.

We also based the assessment of the number of necessary additional education and qualification needs for workers engaged in roof insulation or roofing replacement on the answers of respondents who have been performing this type of work for many years. Comparing the data with those that estimate the number of workers needed to achieve the energy goals by 2030, we conclude that additional education and qualifications are needed for a total of 3,420 workers, all for the purpose of contributing to the achievement of the energy goals by 2030.

Looking at the data obtained from craftsmen and entrepreneurs engaged in the installation of windows and doors, we learn that 41% of them have mediocre and/or poor knowledge of energy-efficient technologies and systems and would definitely like to know more. All respondents use these systems exclusively or do so at the request of investors.

Additional education and qualifications will be needed for 2,470 workers engaged in the installation of windows and doors. The assessment, like the previous ones, is based on the responses of craftsmen and entrepreneurs who deal with this type of work on the one hand and the estimated number of qualified workers to achieve the energy goals by 2030.

Taking into account the answers to the surveys, a total of about 10,000 EE VET workers will need to be trained by 20230. As per the *National Action Plan for the development of skills related to energy efficiency restoration and post-earthquake restoration* [6], the training of 500 workers through adult education programs for post-earthquake reconstruction and energy restoration by the end of the second quarter of 2026 is estimated. During the implementation of CROSKILLS II education, 330 workers and 120 trainers were trained in less than a year.

To ensure quality construction and renovation, it is essential to have a workforce that possesses knowledge of energy-efficient technologies, renewable sources, and green skills which one part of the workforce has already acquired. As a result, it is estimated that annually, a minimum of 500 and a maximum of 1200 workers need to be trained to acquire the necessary skills and knowledge for wall insulation, roof insulation and installation of door and windows. This is considered achievable.

The total estimated number of workers required for RES systems per year is given in Table 50 (2.530). It is assumed that 20% of these workers need to educate per year until 2030, respectively 500 per year. It should be emphasized that all RES workers and installers are obligated to be trained and certified ccording to the Ordinance on requirements and criteria for establishing a quality system for services and works for certification of installers of renewable energy sources - photovoltaic systems, solar thermal systems, small biomass boilers and furnaces and shallow geothermal systems and heat pumps [31] [32] [33] [34].

Based on the analysis given in Table 48 and Table 49, it is estimated that 5,800 engineers need to achieve energy efficiency goals in the building i.e. 1450 per profession. For the purposes of determining the number of engineers that need to be trained annually, the following assumptions were taken into account: 30% for civil engineers, 20% for architectures, and 10% for mechanical and electrical engineers. The courses related to EE are taken by a larger number of students in architecture (because some of these courses are compulsory for all students) compared to civil engineers (where the courses are optional). The percentage for mechanical and electrical engineers is lower because the implementation of the RES and electrical systems necessarily requires knowledge of technology operation. Based on this, it is necessary to educate annually 435 civil engineers, 290 architects, 145 mechanical engineers and 145 electrical engineers with a note on the necessity of permanent training for all engineers in the field of energy efficiency, green construction, digitalization, sustainability and others.

Croatia has regulations that control the training of VET workers for the EE and RES: *Ordinance on education and certification system of construction workers working on the installation of building components which affect the energy efficiency of buildings and Ordinance on requirements and criteria for establishing a quality system for services and works for certification of installers of renewable energy sources - photovoltaic systems, solar thermal systems, small biomass boilers and furnaces and shallow geothermal systems and heat pumps* [31]–[34], [38]. The regulations provide the conditions for issuing consent to training providers, which also includes conditions for persons conducting selection training (trainers). As part of the CROSKILLS II training course, 120 trainers were trained, which is considered sufficient for the education of VET workers in energy efficiency. However, all professionals must undergo training in order to train VET workers in energy efficiency and renewable energy sources. The regulations define the conditions that trainers and training centers must meet, and the future education of workers must be carried out in accordance with the aforementioned regulations. The existing programs for the training of trainers and the training of workers should be adjusted in accordance with the necessary skills needed specified in chapter 7.3. and should be adjusted to the additional requirements for financing education through vouchers for green jobs. Thus, for example, the education program created as part of the CROSKILLS II project needs to be revised and harmonized with market needs.

For the purposes of training engineers, 15 trainers from construction and architecture are needed, as well as 10 trainers from the field of mechanical engineering and 10 from the field of electrical engineering. In addition, it is necessary to create training programs for engineers that include all the necessary equipment (models, presentations, literature) and to adapt the training for the area of design and the area of supervision and construction. The minimum education for a particular profession for level 6 and 7 would have to last 10 hours. Courses and professional development programs should be done by the Croatian Chamber of Architects, the Croatian Chamber of Civil Engineers, the Croatian Chamber of Electrical Engineers and the Croatian Chamber of Mechanical Engineers and other professional organizations, universities, polytechnics and other legal entities which receive the approval of the Ministry of Spatial Planning, Construction and State Property for the professional training program training according to the provisions of *Ordinance on the professional training of persons performing spatial arrangement and construction jobs* (OG 55/2020) [9].

Table 53 Qualification needs per year

	Type of works	Estimation	Qualification needs per year	European qualification framework level
VET workers (blue collar workers)	Wall insulation	3.760	Min 500 Max 1200	Level 4. and 5.
	Roof insulation / replacement	3.420		
	Carpentry replacement	2.470		
	RES	2.530	500	
Engineers (white collar workers)	Civil Engineering	1.450	435	Level 6. and 7.
	Architecture	1.450	290	
	Mechanical Engineering	1.450	145	
	Electrical Engineering	1.450	145	

7.4.1. Qualification standards entered into the Croatian qualification framework

Vocational education and training is offered at levels 2 to 5 of the Croatian Qualifications Framework, which corresponds to the same levels of the European Qualifications Framework (EQF). Most regular vocational education and training programs last three or four years and lead to the acquisition of formal high school vocational qualifications at level 3 and 4 of the EQF. Vocational education and training programs after secondary education, at level 5 of the EQF, are provided for by the *Act on the Croatian Qualifications Framework* (2013) [7] and the *National Curriculum for Vocational Education* (2018) [8] as the vocational specialist training programs at the post-secondary level, but up to now they have not yet been introduced into the system.

The introduction of new curricula is planned (as experimental or regular) from the school year 2024/25.

The Croatian Qualifications Framework (HKO) was reviewed in detail, and by June 20, 2023, the qualification standards listed below have been written in Table 54, Table 55 and Table 56.

In the construction, geodesy and architecture sector, 12 qualification standards have been registered.

Table 54 Construction, geodesy and architecture qualification standards

	Name of the standard	HKO level	EQF
1.	Masonry technician	4.2	4
2.	Spatial data specialist	5	5
3.	Technician of geodesy and geoinformatics	4.2	4
4.	ZIS specialist	5	5
5.	Construction technician	4.2	4
6.	Manager of works in construction	5	5
7.	Construction worker for wooden structures and roofs	4.1	4
8.	Architectural technician	4.2	4
9.	Tiler for floors and walls	4.1	4
10.	Operator of construction machinery	4.1	4
11.	Construction worker for reinforced concrete works	4.1	4
12.	Specialist in sustainable and energy-efficient construction	5	5

Qualification standard for a worker for sustainable construction (level 4.1) is under development. There has been 36 occupational standards with 309 sets of competences registered by June 20, 2023.

16 requests are in the process of being submitted, 12 requests are being processed after evaluation. Curricula were analysed through which learning outcomes related to energy-efficient construction, environmental protection and sustainable construction were introduced.

The construction technician qualification standard was written from the construction technician occupational standard. The learning outcomes are numerous, and we singled out only a few: explain the basic concepts of environmental and nature protection, predict the impact of construction waste and its processing on humans and the environment, explain what ecology and environmental protection are, define the basics of environmental protection in construction, describe the components of the environment (soil, water, air...) and recognize their protection measures, list examples of sustainable management of construction waste, calculate heat losses and water vapor diffusion of individual structures with the application of valid laws and regulations, recognize building materials and products that are used as thermal and sound insulation, determine the parameters for the calculation of the thermal properties of a family house, create a certificate of the energy properties of a family house, explain terms related to water, water resources and their impact on the environment, determine the basic principles and features of energy-efficient and sustainable construction, describe the properties of a low-energy house, passive houses, zero-energy houses, autonomous houses and houses with excess energy, analyze the energy consumption of low-energy and passive houses, analyze the performance of efficient heating systems of low-energy and passive houses, analyze the design of a passive solar house...

Construction worker for wooden structures and roofs is written from the occupational standards of carpenter and roofer. From the specified qualification standard, the learning outcomes are as follows: list the instruments for protecting the environment and nature during construction, describe the impact of construction waste and its processing on humans and the environment, propose a method of disposal of construction waste, explain the basic concepts of environmental and nature protection, prepare an analysis of construction waste disposal , distinguish equipment for disposal of waste materials in accordance with regulations, argue the importance and method of rational use of materials and energy in the formwork execution process, dispose of unused waste material, dispose of unused waste material in large-area formwork, describe the role and method of covering with solar tiles, describe ways and possibilities of making green roofs...

Floor and wall tiler is written from the occupational standards of floor and wall tiler and tiler - tiler. To compare the similarities and differences of traditional and modern construction and to apply technical and ecological improvements in work are the learning outcomes of this qualification standard.

A construction worker for reinforced concrete works is written from the occupational standards of rebar worker, mason, insulator, facade worker. The learning outcomes for the construction worker qualification standard for reinforced concrete works are: explain the equipment for disposing of waste materials in accordance with regulations, describe the function and properties of thermal, sound and waterproofing, places and methods of installation, explain the materials for performing thermal and sound insulation of walls and floors, and apply technical and environmental improvements in work.

A construction worker for sustainable construction is written from the occupational standards of dry construction fitter and green construction fitter. The specified qualification standard contains the following learning outcomes: describe the physical-mechanical properties of natural materials with regard to their role in green construction, list the materials we use in green construction for the production of final finished products, describe the physical-mechanical properties of insulating materials with regard to their role in green construction, differentiate materials according to graphic marking and list the main producers of the same, recognize types of renewable sources according to markings and field of application, distinguish connecting, decorative, protective and super-strength means for mounting elements of green construction, draw in floor plan and cross-section structural elements in prefab green construction and recognize them in drawings, interpret the technology of processing wooden products for the production of wooden structures in green construction, describe the procedure for implementing product quality control during the delivery and installation of materials, equipment and technology, list products for joining, fixing, insulating and filling joints, decoration and protection in green construction , distinguish the statement of properties and technical instructions for installing products in green construction, explain the function and properties of thermal, sound and waterproofing, places and methods of installation, describe the technical documentation of manufacturers of insulating materials according to different types and systems, distinguish and use materials and technology of waterproofing, heat and sound insulation, draw characteristic details of the performance of waterproofing and thermal insulation in green construction facilities, control the quality of the insulation performance in accordance with the manufacturer's technical instructions and standards, define the elements of green construction and the possibility of connections to the necessary infrastructure, determine the elements of the project for the execution of assembly works in the green construction, create a proof of measures and calculate the required amount of materials, the duration of activities and the required workforce, define a work plan with the requirements of the concept of green construction, energy efficiency and renewable energy sources, prepare the base for the installation of green construction elements in accordance with the project documentation...

In the mechanical engineering, shipbuilding and metallurgy sector, 22 qualification standards have been published, of which 7 have learning outcomes related to sustainable construction, Table 56.

Table 55 Qualification standards for mechanical engineering, shipbuilding and metallurgy

	Name of the standard	HKO level	EQF
1.	Service fitter for renewable energy sources	4.1	4
2.	Specialist in mechanical engineering	5	5
3.	Housekeeper - janitor	4.1	4
4.	Manufacturer and fitter of aluminum and PVC joinery	4.2	4
5.	Energy technician	4.2	4
6.	Installer of home installations	4.1	4
7.	Specialist for mechanical installations in construction	5	5

In the electrical engineering and informatics sector, 61 qualification standards have been published, of which 6 have learning outcomes related to sustainable construction.

Table 56 Qualification standards for electrical engineering and informatics

	Name of the standard	HKO level	EQF
1.	Electric fitter	4.1	4
2.	Specialist in sustainable energy systems	5	5
3.	Electrician	4.1	4
4.	Electrical technician	4.2	4
5.	Specialist in advanced building management	5	5
6.	Specialist in solar energy systems	5	5

7.5. Monitoring needs

The analysis established that in the Republic of Croatia there is no system for monitoring and controlling the knowledge and skills of workers related to energy renovation and building in the construction sector although there are Regulations (Official Gazette 33/15, 39/15, 56/15, 12/17 and 67/17) [1]–[5] which established a system for determining the quality of services and works as well as certification of construction workers and installers who work on the installation of energy efficiency systems in the building industry.

Within the framework of the National Roadmap, it is necessary to solve the problem of monitoring:

- the number of workers, engineers and architects who have the required knowledge and skills by creating and regularly updating publicly available registers
- the required competences and skills of workers and engineers working on energy efficiency tasks through questionnaires and surveys.

Early warning systems for the risks of insufficient skills are also not current, especially for the needs of the interests of the CRO skills RELOAD project. The project partners emphasized that monitoring the competences and control of acquired knowledge of workers in the context of energy-efficient systems and technologies is extremely important, therefore, after the end of the project, a group of experts composed of representatives of the project partners and the real sector will be formed. The task of the working group is to monitor trends in the application of energy-efficient systems in buildings at the national level in a half-yearly period. A periodic examination of the knowledge and skills of workers and changes among those who use energy-efficient systems in their business will take place through questionnaires that will be distributed to entrepreneurs and craftsmen through the channels of professional chambers that have databases. Likewise, in order to regularly maintain and raise awareness of the importance of renewable energy sources and the implementation of such systems in construction, workshops will be organized where crucial deficiencies in workers' knowledge will be detected and adequate education will be offered.

8. Barriers

The holistic approach takes into consideration all aspects and factors which affect the undertaken and planned efforts in the construction sector, to achieve the goals for 2030. Fulfilling those ambitions is still constrained by many ambiguities and challenges regarding acquisition of qualifications and unpredictable situations that could possibly mitigate their realization.

To accomplish the aims for energy efficiency in the building industry in the country, construction companies have lately found themselves in high demand for renovation while at the same time struggling with a lack of qualified workforce.

Relevant stakeholders from the industry have taken part in an internal questionnaire from the Croatia Green Building Council (30 representatives of CGBC's member base) and stated crucial obstacles regarding qualifications for energy efficiency from their part (Figure 55).

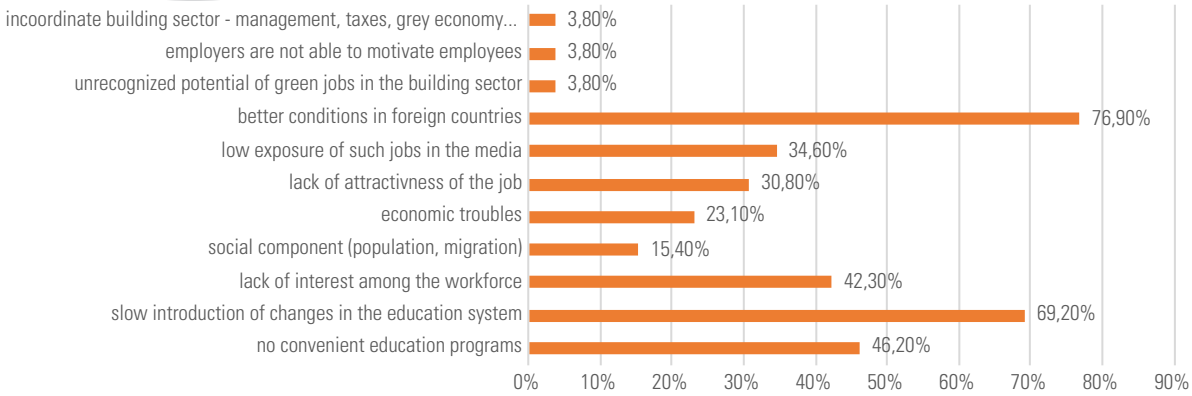

Figure 55 Reasons for workforce deficiency in the building sector of Croatia.

According to the data, the main challenges are deficiency of workforce caused by better conditions in foreign countries (76.9%) as well as missing convenient education programs (42.3%) and a very slow introduction of changes into the education system (69.2%).

Vocational education

Considering the social aspect, the main impediment are distorted opinions of young people towards occupations from the technical scope. Such occupations lack attractiveness and usually don't fulfil the enrolment quotas in the schools that provide those programs [1]. Furthermore, according to the statistics provided by the VET schools, some programs have no enrolled students at all, e.g. rebar workers. Consequently, the situation describes the initial problem of workforce and expert deficiency on the market. To increase the popularity of such programs in the VET school education, a scholarship system was established, yet it wasn't particularly successful in global since it depends on individual enthusiasm and activities of school, county or companies who noticed the importance of scholarships.

Document *National action plan for skills development in the context of green jobs related to energy and post-earthquake reconstruction* [1] highlights that this level of education (level 4) is **missing practical knowledge** as a crucial part of providing needed skills. That leads to extenuation of education programs and poor quality and competitiveness of the workforce. Vocational education still doesn't cope well with market needs which causes significant disproportion of labour market [5].

High education

According to the document National action plan for skills development in the context of green jobs related to energy and post-earthquake reconstruction [1] in the higher education programs, there is insufficient interdisciplinarity, **a lack of practical application of scientific research and practical work using innovative solutions.** The authors claim [1] that the curricula of higher education institutions often do not follow the latest findings but are established on outdated knowledge and are rarely updated, which often leads to a reduction in the quality of preparing professionals for the labour market characterized by frequent and rapid changes. Additionally, curricula are often specialized for a specific area of interest and rarely include the adoption of knowledge and skills from other disciplines. This ultimately leads to a lack of interdisciplinary knowledge, especially in the context of energy efficiency jobs. However, analysis of high education in Chapter 5.2. showed that there are 13 specialized programmes (Table 39) and more than 110 courses specifically focus on promoting sustainability, enhancing energy efficiency, harnessing renewable energy sources, and facilitating digitalization in the high-level education for civil engineering, architecture, mechanical and electrical engineering. However, **most subjects are optional and depend on the students' interest** in the given topic which leads to a very small number of qualified engineers compared to the needs of the market.

Foreign workforce

A notable problem in Croatia is the lack of workforce which is additionally confirmed by the analyses in Chapter 7 of this document. Namely, the construction sector has suffered a significant loss of domestic labour contingent as a result of the economic crisis that occurred in 2008 and in the years following, given that a high rate of workers emigrated to more developed countries.

As a solution to this problem, the only option is to employ foreign workers. These workers are often from the countries in the region, such as neighbouring Bosnia and Herzegovina, Kosovo, Macedonia, and Serbia. However, in recent years, there has been an increasing number of workers from more distant countries, such as Nepal, India, etc. The largest number of residence and work permits in 2022 was issued for the construction sector for the occupations mason, carpenter and construction worker (please see chapter 7.2. Workforce development). The existing legal structure that applies to the employment of foreigners does not match the current needs of the construction sector for the labour force.

Furthermore, a notable social challenge associated with employing foreign workers is the language barrier. This obstacle gives rise to difficulties in comprehending job-related terminology and hampers effective communication during work processes. Additionally, lengthy administrative procedures and inadequate coordination among institutions constitute an added burden, significantly impeding the education and employment of both local individuals and foreign nationals alike.

According to the information obtained from the relevant industry representatives, 34.6% of the respondents have highlighted language and unexperienced workforce (23.1%) as an obstacle when working with foreign nationals (Figure 56).

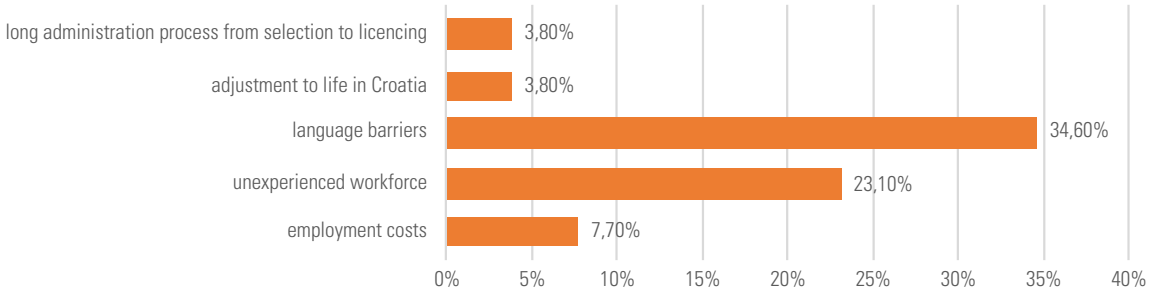

Figure 56 Problems encountered by contractors who employ foreign nationals.

Small and Medium Enterprises

Qualification challenges for companies (small and medium enterprises, SME) are largely due to certain difficulties faced by their employees' access to training in the field of energy-efficient construction. Some of these challenges include:

- Financial constraints: SMEs often face financial limitations that hinder their ability to afford employee training programs due to limited resources.
- Time constraints: SMEs may struggle to allocate sufficient time and resources for employees to participate in training, as they cannot afford to have them take extended time off work.
- Limited access to training: SMEs encounter difficulties in accessing training programs and resources that are typically more readily available to larger companies, making it challenging to find suitable training opportunities for their employees.
- Limited awareness of available training: SMEs may lack awareness of the diverse range of training programs available to them, making it harder for them to identify and access the specific training their employees require.
- Limited language skills: In situations where training programs are conducted in a language unfamiliar to employees, language barriers can impede their ability to attend and actively participate in the training sessions.
- Limited flexibility in training: SMEs have unique needs and demands that may not align with standardized training programs, which can make it difficult to find training options that cater to their specific requirements.
- Limited consistency and sustainability: SMEs often lack the capacity to consistently implement and sustain training programs within the workplace, making it challenging to maintain the long-term benefits and results of the training initiatives.

Training programmes

The challenges and barriers for existing training programmes are as follow:

- The lack of transparency and standardization in the construction sector, which can make it difficult for workers to understand the qualifications and certifications required for different roles and levels of work they perform. This leads to a lack of investment in the sector, as workers hesitate to attend training and qualifications without a clear understanding of its benefits.
- Furthermore, there is a lack of adequate professional development for vocational subject teachers and their connection to work-based learning. There is an insufficient number of qualified trainers available to facilitate the training programs. This scarcity of experienced and knowledgeable trainers further exacerbates the barriers to effective skills development within the vocational sector.
- Unfortunately, the implementation of training programs for VET workers in accordance with Croatian regulations (Official Gazette 33/15, 39/15, 56/15, 12/17, and 67/17) [1]–[5] has been lacking. These regulations serve as a crucial frame-

work for establishing a system to ensure the quality of services and work, as well as the certification of construction workers and installers involved in the installation of energy efficiency systems in the building industry. It is essential to address this gap and prioritize the implementation of training initiatives to uphold the highest standards in the industry.

- The Republic of Croatia recognizes only formally acquired secondary education, while non-formal education is not yet legally regulated.
- Furthermore, there is a notable lack of necessary equipment in training centres to facilitate the practical component of classes. It is crucial to invest in modern and up-to-date equipment that aligns with industry standards, enabling students to gain hands-on experience and develop the practical skills required in their respective fields.
- Additionally, it has been observed that existing training programs are often excessively lengthy, requiring a significant time commitment from participants. To optimize the learning experience and better align with the needs of the industry, it is essential to consider streamlining these programs by reducing the number of instructional hours. This adjustment would allow for a greater emphasis on practical training, enabling learners to acquire hands-on skills and experience in a more efficient manner. A successful model in this regard is the CROSKILLS II education program, which serves as an excellent example of a training approach that balances theoretical knowledge with practical application, leading to enhanced learning outcomes and increased employability.

National qualification platform inputs

Regarding education and the necessary changes that are being sought, it is of a paramount importance for acontinuous cooperation among the members of the National Qualifications Platform (NQP), which can contribute to the findings of potential solutions for improving the existing system of additional qualifications in the construction sector and their position and recognition in the market.

As a support and confirmation for all the previously discussed barriers, great feedback was provided by the first National qualification platform (NQP) meeting. The key NQP stakeholders from the construction sector, educational and relevant public institutions discussed the problems they are facing and provided possible solutions:

- Vocational schools today face a significant challenge of insufficient funding to ensure high-quality teaching and practical training.
- The importance of green public procurement, which is currently not being implemented, has been emphasized. In the current public procurement system, criteria are provided for engineers (qualification needs to be proven with references), while there are no criteria for VET workers, nor are they included in the public procurement. Since a portion of building renovations, including seismic and energy renovations, are funded by public funds, it is possible to introduce additional scoring in the public procurement process for contractors who employ qualified workforce or support the education of their employees. This would incentivize the hiring of skilled workers and promote the professional development of the workforce within the construction industry.
- Chambers of Trades should take the initiative and collaborate with the construction material manufacturers to organize educational programs. Currently, the training sessions organized by manufacturers tend to have a commercial focus, and the organization of such events by a chamber that brings together all available manufacturers would represent education in the public interest. This approach would ensure a strategic and coordinated effort, rather than an ad-hoc and fragmented approach, thereby promoting comprehensive and beneficial learning opportunities for professionals in the industry.

9. Conclusions

When analyzing and processing data of an energy and statistical nature, the most common problem was to obtain data that are characteristic only for the building sector. Most often, the data related to the building sector are added to the data for the construction sector or are shown only partially, so that in many cases it is not possible to compile a complete picture of an area. This applies both to data on the number of legal entities and trades related to building construction, as well as to data on the number and structure of employees; both for data on energy consumption and types of energy, as well as for data on energy from RES produced only in buildings or for the needs of buildings; and often data of the same type in the same document for the same case do not match, and the user of the document must make a decision as to which data to take as correct. We were all the more surprised by this because buildings, construction and energy consumption in buildings always stand out as an important factor in the field of consumption of all types of energy, but also in the field of energy policies. This is precisely why databases, statistical data, analyses, plans, programs and strategies should always contain building construction as a special category with easily accessible data and overview plans. In addition, the building industry is not just one category, but is divided into residential and non-residential buildings, or into family houses and buildings of the commercial sector, etc., and when possible, the data should be structured taking into account these characteristics of the building industry. However, this is not the case and we had the opportunity to constantly witness this during the analysis.

Concretely, this means that e.g. data on the consumption and production of all forms of energy in the building industry would have to be presented more completely and directly, and above all, e.g. installed and available capacities for energy production from RES in buildings and for the needs of buildings. In addition, it should be avoided to display or name data in a way that is not common, so that it is necessary to consult with experts if they do not understand what it is about (e.g. "resource energy" or "resource heat").

More specifically, for one of the most important areas in the building industry – zero energy buildings – there is no readily available data on the number of buildings built or areas. This deficiency should be eliminated as soon as possible.

Key indicators confirm that the growth of the construction activity started in 2016 and continued in 2022 with an average growth of the construction works index of almost five percent. Data on the issued construction permits suggest that similar trends will continue in the coming period. Construction activity in the next period will be supported by the planned renovation of buildings damaged in the earthquake, infrastructure projects and investments in tourism.

The number of employees in the construction sector is growing for the sixth consecutive year, and last year for the first time the number of employees in construction exceeded the level recorded before the outbreak of the global financial crisis in 2008, by 2,200 workers.

The lack of qualified labor in the construction industry is reflected in the fact that the import of labor has increased drastically over the past few years, increasingly from countries with a different educational system and knowledge of construction technologies. The education of the aforementioned workers in the context of knowledge about energy-efficient technologies will represent a significant challenge for achieving the goals by 2030.

Analyzing the tradesmen's answers to the questions in order to obtain more precise information about the knowledge and skills of the tradesmen and their workers, we determined that, depending on the work they perform - between 40% and 60% of

the tradesmen believe that they do not know enough about energy-efficient technologies and would like to know more.

During the analysis of vocational education, insufficient interest of students in three-year vocational occupations was observed, resulting in a mismatch with the needs of the labor market. In addition, professional occupations have an inadequate reputation in the public (occupations are not attractive, physically very demanding and undervalued). There is insufficient support from competent ministries and professional chambers for mentors (employers) with whom students do practical classes, and insufficient capacities of employers, especially in smaller environments, for the implementation of work-based learning. Uneven equipment of vocational schools, especially school practicums, was noticed, usually insufficient for the needs of quality implementation of vocational programs. In addition, there is insufficient training of teachers of professional subjects and their connection with work-based learning, as well as insufficient monitoring of the quality of the program execution and the absence of external evaluation.

In the qualification standards entered into the Croatian qualification framework where the enrollment of new curricula is foreseen (as experimental or regular) from the school year 2024/2025 earning outcomes related to energy-efficient construction, environmental protection and sustainable construction were introduced.

An in-depth analysis of the currently available courses was made where the contents of individual subjects and learning outcomes (if defined) were reviewed and grouped according to the specific skills that the current higher education system already addresses. However, additional analysis showed that few students enter the labor market with knowledge and skills related to EE and OIE, and previous analyzes of the workforce working in the field of EE and BIM for 10 years showed low scores of self-assessment of knowledge and understanding of EE and BIM -And.

In order to achieve the goals of energy efficiency in the building industry by 2030, it is estimated that approximately 45,000 workforce will be needed annually, i.e. 24,530 VET workers (level 4) and 5,800 engineers (level 7), Table 57 .

It was estimated that a minimum of 500 construction workers (level 4 and 5), 500 RES workers, 435 civil engineers, 290 architects, 145 mechanical engineers and 145 electrical engineers need to be trained annually in order to acquire the necessary skills and knowledge (Table 57) .

Croatia has regulations that regulate the training of professional workers for energy efficiency (EnU) and renewable energy sources (RES) in building construction (level 4 and 5): *Rulebook on the system of education and certification of construction workers who work on the installation of building parts that affect the energy efficiency of buildings* . *Rulebook on requirements and criteria for the establishment of a quality system of services and works for the certification of installers of renewable energy sources - photovoltaic systems, solar thermal systems, small biomass boilers and furnaces, and shallow geothermal systems and heat pumps* [1]–[5] . The Regulations define the conditions that trainers and training centers must meet, and the future education of workers must take place in accordance with the aforementioned Regulations. The existing training programs for trainers and workers should be adapted in accordance with the necessary skills specified in chapter 7.3. and it is also important to harmonize and adapt additional conditions for financing education through vouchers for green jobs. For the purposes of training engineers, 15 trainers from the fields of construction and architecture are needed, as well as 10 trainers from the field of mechanical engineering and 10 from the field of electrical engineering. In addition, it is necessary to create training programs for engineers that include all the necessary equipment (models, presentations, literature) and to adapt the training for the area of design and the area of supervision and execution. The minimum education for a particular profession for level 6 and 7 would have to last 10 hours. Professional training courses and programs should be conducted by institutions that have the approval of the Ministry of

Physical Planning, Construction and State Assets or a professional training program according to the provisions of the Ordinance on professional training of *persons performing spatial planning and construction tasks* (Official Gazette 55/2020) [6] .

The lack of interest in secondary education programs results in a lack of labor and specialists in the market. Moreover, at this level of education, there is a noticeable lack of practical knowledge and skills, which leads to a lack of quality workforce. One of the barriers is the lack of modernized vocational education profiles and the very slow introduction of current technologies into the education system. The lack of domestic labor leads to dependence on foreign workers. This issue entails the existence of language barriers and long-term administrative processes that hinder the presentation and slow down the employment and training of foreign workers. On the other hand, in terms of qualifications, small and medium-sized enterprises face challenges such as time and financial constraints, limited information about available trainings and their flexibility.

Solving the problem of excess occupations in vocational education and training (economics and trade), the strategic document of the Republic of Croatia, the *National Recovery and Resilience Plan 2021-2026*, lists goals and budget allocations aimed at increasing the number of students who transfer from vocational occupations to high school programs. Unfortunately, the document missed a historic opportunity to allocate funds and initiate transformational measures for deficient occupations in vocational education in the construction, architecture, electrical and mechanical engineering sectors, especially in activities related to increasing student enrollment.

The analysis determined that in the Republic of Croatia there is no system for monitoring and controlling the knowledge and skills of workers related to energy renovation, therefore it is necessary to form an informal body/consortium after the project that will monitor the development and implementation of good practices on a semi-annual basis.

Table 57 Estimated number of manpower required annually

	Types of works	Estimated number of workforce to reach 2030 goals	Per year necessary qualifications	European qualifications framework
VET workers (Vocational occupations)	Wall isolation	9,400	Minimum 500 Maximum 1200	Levels 4. and 5.
	Roof insulation / replacement	6,000		
	Replacement carpentry	6,600		
	Renewable sources energy	2,530	500	
Engineers (high education)	Construction	1,450	435	Levels 6. and 7.
	Architecture	1,450	290	
	Mechanical engineering	1,450	145	
	Electrical engineering	1.450	145	

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Glossary

ASOO	Agency for Vocational Education and Training and Adult Education (VET Agency)
EE	energy efficiency
RES	renewable energy sources
MZO	Ministry of Science and Education
HZZ	Croatian Employment Service
FINA	Financial Agency
HOK	Croatian Chamber of Trades and Crafts
EU	European union
JMO	Integrated educational model
DO	Dual model
EPBD	Energy Performance of Buildings Directive
RH	Republic of Croatia
BIM	Building Information Modelling
UNDP	United Nations Development Programme
EQF	European Qualifications Framework
CROQF	Croatian Qualifications Framework
GVA	gross value added
GDP	gross domestic product
DZS	Croatian Bureau of Statistics
STS	solar heating systems
PV	systems photovoltaic systems
HROTE	Croatian Energy Market Operator
SDG	Sustainable development goals
SME	Small and medium enterprises
NZEB	Nearly zero-emission building