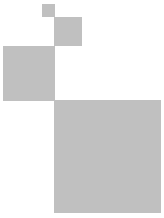
ENERGY EFFICIENCY TRENDS AND POLICIES IN CROATIA

Date: November, 2021



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EXECUTIVE SUMMARY

The report briefly presents data on energy efficiency in Croatia in three sectors – buildings, transport and industry. The energy efficiency index (ODEX) is also presented. This index monitors the long-term development of energy efficiency in buildings, transport and industry.

Total energy consumption in Croatia in 2020 amounted to 386.8 PJ, which is 4.7 percent lower than in the previous year. At the same time, the growth rate of real gross domestic product (GDP) was -8.0 percent. The decline in total economic activity in 2020, due to the COVID-19 pandemic, was chiefly caused by a decrease in exports of services and personal consumption. Government consumption was the only component of domestic demand with a positive contribution to GDP change.

Energy intensity in the Republic of Croatia in 2020 amounted to 108.3 kgoe / 103 US$ 2010 (according to purchasing power parity), 2.8 percent higher than the average in the European Union (EU 27).

Final energy consumption in 2020 amounted to 269.5 PJ and decreased by 6.7 percent compared to the previous year. In the final energy consumption structure, industry participated with 16.1 percent, transport with 31.3 percent, and general consumption with 52.7 percent.

The share of renewable energy sources in gross final energy consumption in 2020 is estimated at 29.6 percent (according to the EUROSTAT methodology), 1.1 percentage points higher than in 2019.

In the observed period from 2000 to 2020, a slight decline in the energy efficiency index (ODEX) was evident, i.e., an improvement in energy efficiency in the industrial and household sectors. In the transport sector, there has been an increase of 4 percent in the last two years, which affects the growth of the total ODEX.

1. ECONOMIC AND ENERGY EFFICIENCY CONTEXT

1.1. Economic context

In the period from 2000 to 2008, the average GDP growth rate was 4.2 percent. During this time period GDP growth was driven by strong domestic demand growth. During the following years 6 years, from 2009 until 2014 we witnessed GDP decline in Croatia due to the global crisis which was driven by fall of global demand and sudden stop in capital flows. Real GDP growth during global financial crisis dropped by 12.6 percent . During 2020, there was a decline in economic activity: the annual growth rate of real GDP in 2020 was -8.0 percent, and in the previous year 2.9 percent. The negative impact of the COVID-19 pandemic has affected the domestic economic activity, as well as the economic activity of our most important foreign trade partners (Figure 1.1).

The largest individual contribution to the contraction of economic activity in 2020 was made by the decrease in total exports, mainly the exports of services. At the same time, the imports of goods and services also decreased, but less than total exports. Furthermore, the sharp decline in personal consumption reflected the adverse effect of the pandemic on the household potential as well as on the propensity to spend. In contrast, general government capital investments and consumption went up in the 2020 compared to 2019.

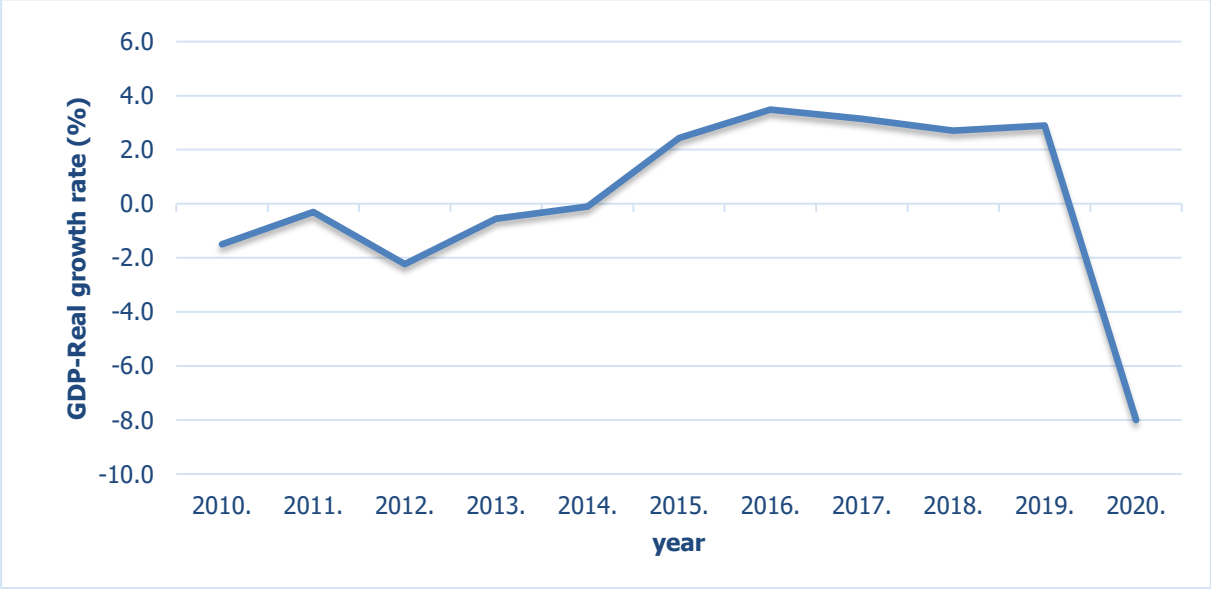


Figure 1.1 GDP - Real growth rates (%), 2010-2020

Source: CBS

The main trends in macroeconomics indicators during 2020 are the following:

- GDP contraction: the annual growth rate of real GDP in 2020 was -8.0 percent compared to 2.9 percent of previous year according to the data from Croatian Bureau of Statistics (CBS). The pandemic of COVID-19 took place in the first quarter of 2020 and continued throughout the whole year. The decline in GDP growth rate in the 2020 is a result of a slowdown in the growth of household consumption expenditure and of a decrease in exports of goods and services, while government consumption was the only component of domestic demand with a positive contribution to GDP change.

- The average annual inflation rate of consumer prices slowed down to 0.1 percent in the whole of 2020, from 0.8 percent in 2019, which was, to the largest extent, a consequence of the decrease in the annual rate of change in the prices of energy (-0.7 percentage point). Going forward, the seasonal decrease in the prices of clothing and footwear together with decrease of the prices of crude oil had a big impact on the average annual inflation rate.

- The highly expansionary monetary policy continued at the end of the year and therefore banks' free reserves reached their historical high. In this way, Croatian National Bank (CNB) ensured a stable exchange rate of the kuna against the euro and contributed to the further relaxation of the financing conditions in the domestic market despite the COVID-19 crisis that marked 2020. The expansive character of monetary policy is reflected in the very low overnight interest rates on money deposits whose value ranged between 0.00 percent and 0.07 percent. The kuna liquidity surplus in 2020 averaged HRK 54.7 bn, which is 15 percent of GDP.

- Continued decline in interest rates: the average interest rate on new housing loans in kuna was 2.5 percent at the end of 2020, while in 2019, it was 2.9 percent.

- Due to the repercussions of the COVID-19 pandemic for the national economy, which required the government's support measures to offset the impact, the general government budget deficit occurred in 2020. The general government generated a consolidated deficit of HRK 27.5 billion, or 7.4 percent of GDP in 2020, with the consolidated general government debt reaching 88.7 percent of GDP, which was 15.9 percentage point higher compared to the same period in 2019, according to the CBS. The deficit thus ended a three-year streak of surplus of the general government

measured by ESA 2010 methodology and after 5 years decline, public debt-to-GDP ratio increased too.

- Unfavourable movements in the current and capital accounts were mitigated by the decline in the foreign trade deficit due to a sharp decline in imports. Merchandise exports proved to be relatively resilient according to the balance of payments data expressed in euros, where an annual decline of 5.4 percent was recorded, while merchandise imports decreased by 10.7 percent because of contraction of domestic household and investment demand, import dependence on exports, which includes tourism, as well as cheaper oil products. The greatest contribution to the reduction of the trade deficit was made in the exchange of energy sources, primarily oil and oil derivatives, road vehicles and food products.

- The Government of the Republic of Croatia adopted the Strategy for the Adoption of the Euro in the Republic of Croatia in May 2018 and appointed a National Council for Euro Adoption responsible for the implementation of the Eurostrategy. The Governor of the Croatian National Bank (CNB) was appointed deputy head of the National Council. On May 27th, 2019, the Government of the Republic of Croatia sent a request to the ECB to establish close cooperation between the ECB and the CNB in supervising credit institutions within the single supervisory mechanism, which is an integral part of the ERM II entry procedure and in the euro area. Kuna was included into ERM II on July 10th, 2020.

1.2. Total energy consumption and intensities

Table 1.1 presents trends in the consumption of energy forms within the total final energy consumption in the period from 2015 to 2020. In 2020, the total final energy consumption decreased by 6.7 percent, compared to the previous year.

From 2015 to 2020, the final energy consumption decreased at an average annual rate of 0.4 percent.

Table 1.1 Final energy consumption by fuel

Source: EIHP

FUELS	2015.	2016.	2017.	2018.	2019.	2020.	2020./19.	2015.-20.
	PJ						%	
Coal and coke	8,14	7,71	8,93	8,57	7,73	7,35	-4,9	-2,0
Biomass	51,02	48,52	47,29	47,08	47,58	48,87	2,7	-0,9
Other renewables	0,81	0,86	0,88	0,90	0,95	0,86	-8,9	1,3
Liquid Fuels	109,18	111,96	118,94	116,63	118,41	101,56	-14,2	-1,4
Gaseous Fuels	33,96	35,06	36,98	37,31	37,51	37,72	0,6	2,1
Electricity	55,15	55,04	57,46	58,03	57,96	54,61	-5,8	-0,2
Heat	16,82	18,19	19,08	17,77	18,71	19,13	2,2	2,6
TOTAL	**275,08**	**277,34**	**289,55**	**286,29**	**288,86**	**270,09**	**-6,5**	**-0,4**

For each sector, ODEX is calculated as a weighted average of sub-sectoral indices of energy efficiency progress; considering that:

- the sub-sectoral indices are calculated from variations of unit energy consumption indicators, measured in physical units and selected to provide the best proxy of energy efficiency progress, from a policy evaluation viewpoint; use of these indices enables the combinations of different units for a given sector, for instance, kWh/appliance, kWh/m2, etc.;
- the weight used to get the weighted aggregate is the share of each sub-sector in the total energy consumption of the sub-sectors considered in the calculation.

Thus, a value of ODEX equal to 90 means a 10% energy efficiency gain. ODEX consists of two parts: the aggregate index and the technical index. The aggregate index considers various influences not linked to energy efficiency, such as climate fluctuations, changes in economic and industrial structures, lifestyle changes (increase in the size of dwelling). The technical index is linked to energy efficiency. The year 2000 is taken as the index year.

In the regarded period between the index year 2000 and 2020, there is a decrease of the energy efficiency index in the economy, which indicates an increase in energy efficiency. The transport sector has had a notable increase in the last two years, about 4%, which influences the rise of the global ODEX. This rise after 2019 indicates the change of the energy use in transport, after a continuous decrease. Figure 1.2 shows the ODEX variations for principal energy consumption sectors.

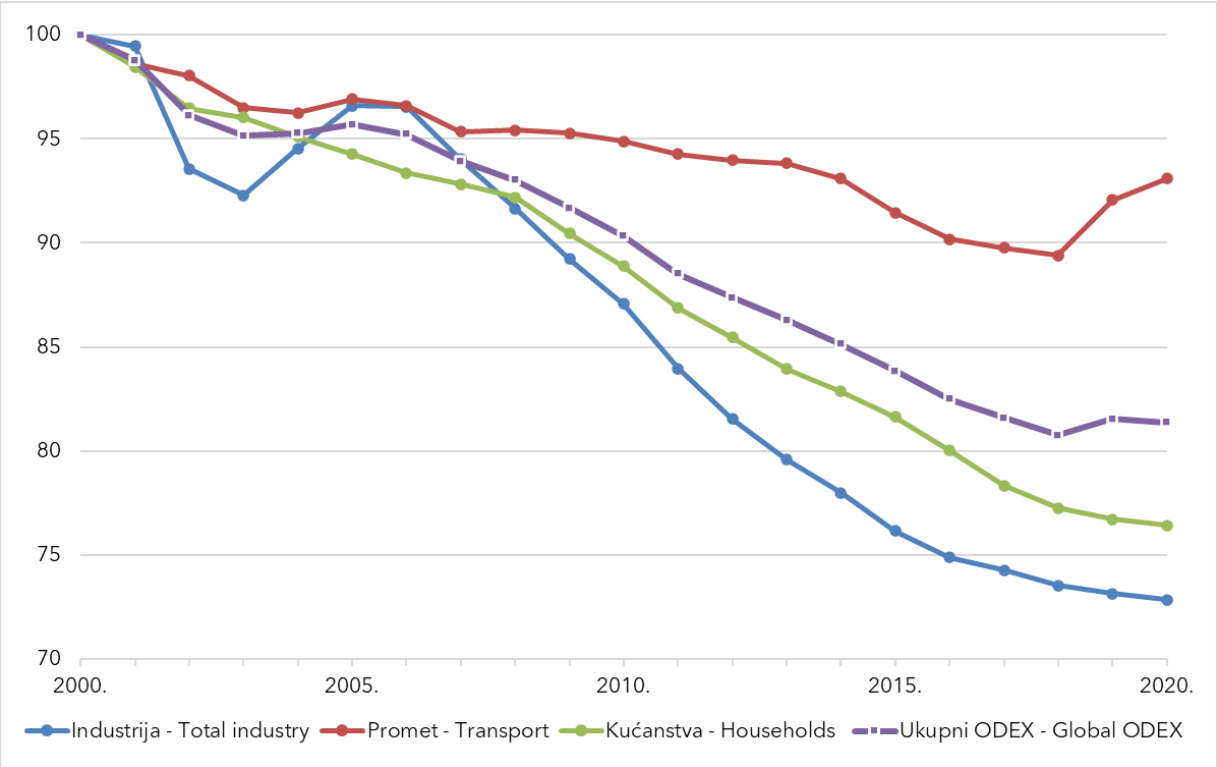


Figure 1.2 Energy efficiency index ODEX, 2000 - 2020

Source: EIHP

The economic indicators are unavoidable factors in the analyses of the rational use of energy. In line with that, the energy intensity combined with economic indices is considered for the selected sectors. The ratio of total consumed energy and gross value added within a specific sector is expressed as the energy intensity for the year observed. The energy intensity indices in final consumption take 2000. as the referent year.

Figure 1.3 depicts the energy intensity indices for individual sectors of direct energy consumption from 2000 to 2019. The trends from the previous period continue in 2020 for all sectors. The energy efficiency in households has the lowest value of all sectors. Most sectors don't have notable changes in energy intensity compared to 2019, and transport, as the most intensive, continues with the increase, for 1,3%.

Regarding all sectors together, the energy intensity index, the energy intensity trend is unchanged, compared with the previous year it is only 1,5% smaller.

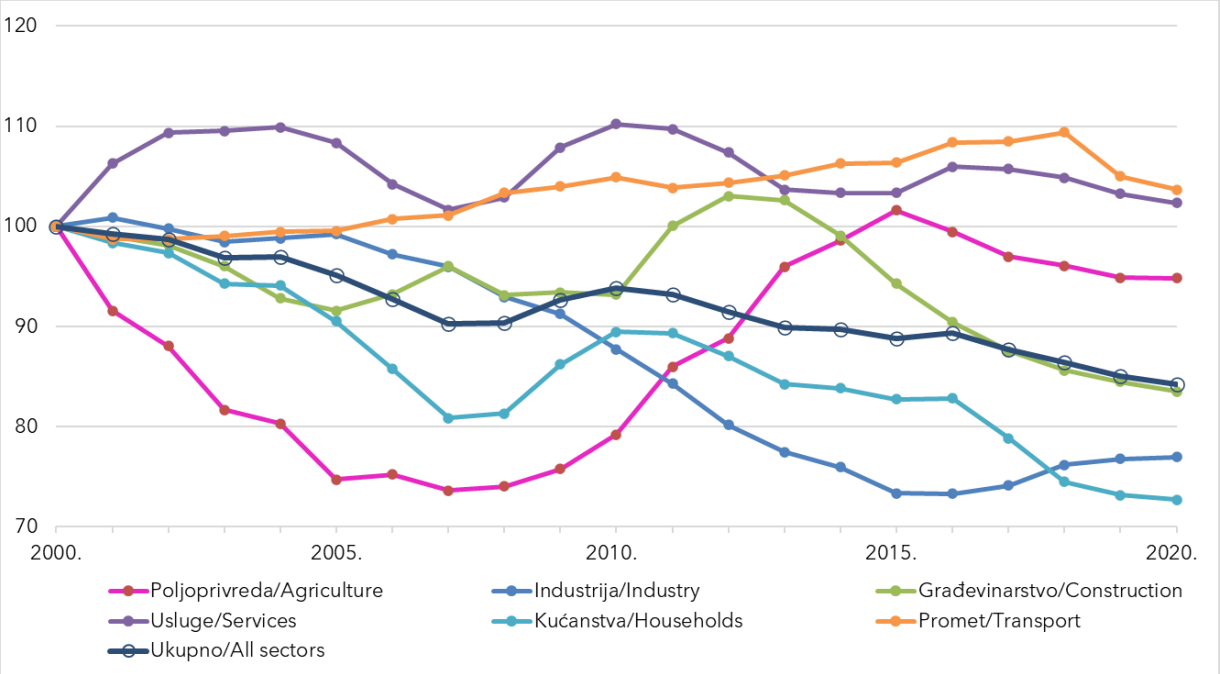


Figure 1.3 Energy intensity indices between 2000 and 2020

Source: EIHP

Primary energy intensity and final energy intensity are also efficiency indicators. Primary energy intensity is the ratio of total energy consumption and gross domestic product, while final energy intensity is the ratio of final energy consumption and gross domestic product (Figure 1.4). The intensity of primary energy consumption maintains the same decreasing trend compared to 2019, and the same trend continues for the final intensity.

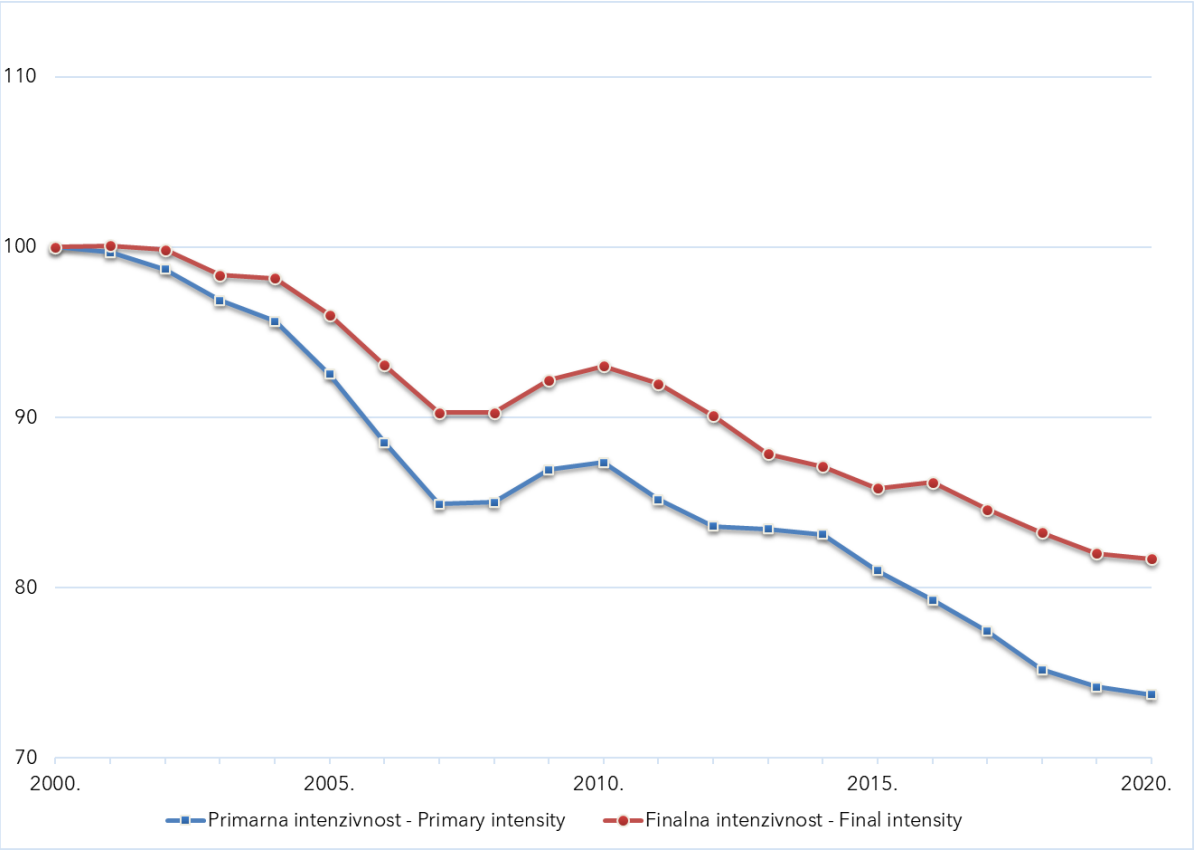


Figure 1.4 Primary to final energy intensity ratio from 2000 to 2020

Source: EIHP

The energy intensities and the derived indicators are often used in the analyses of energy efficiency. Further derived indicators are obtained by observing the change in energy use per unit of product or service and the change in performance in achieving the market value of the product or service. The indices thus obtained are affected by the structural effect and the unit consumption effect.

These analyses compare the realized energy intensity with the intensity from 2000, i.e., the assumed energy consumption in the considered year that would be achieved with the intensity level from 2000, according to the achieved GDP from the given year. The impact of the structural effect is distinguished, i.e., the market indicator from the impact of the unit energy consumption effect that is an indicator of energy efficiency.

Figure 1.5 presents the energy intensity and structural macroeconomic effects up to 2020. The effect of unit consumption has significant variations until 2010, after which it is essentially in a continuous decline. This continuous trend of decreasing relative intensity has continued, with a slightly smaller gradient of decrease in 2020 compared to the previous year. The structural effect, i.e., the impact of the achieved market characteristics on the relative energy intensity,

on the other hand, is more continuous, with a decreasing impact over time compared to the unit consumption effect. In the last two years, the relative intensity, compared to 2000, has been changing trend and rising slightly, in part owing to market disruptions.

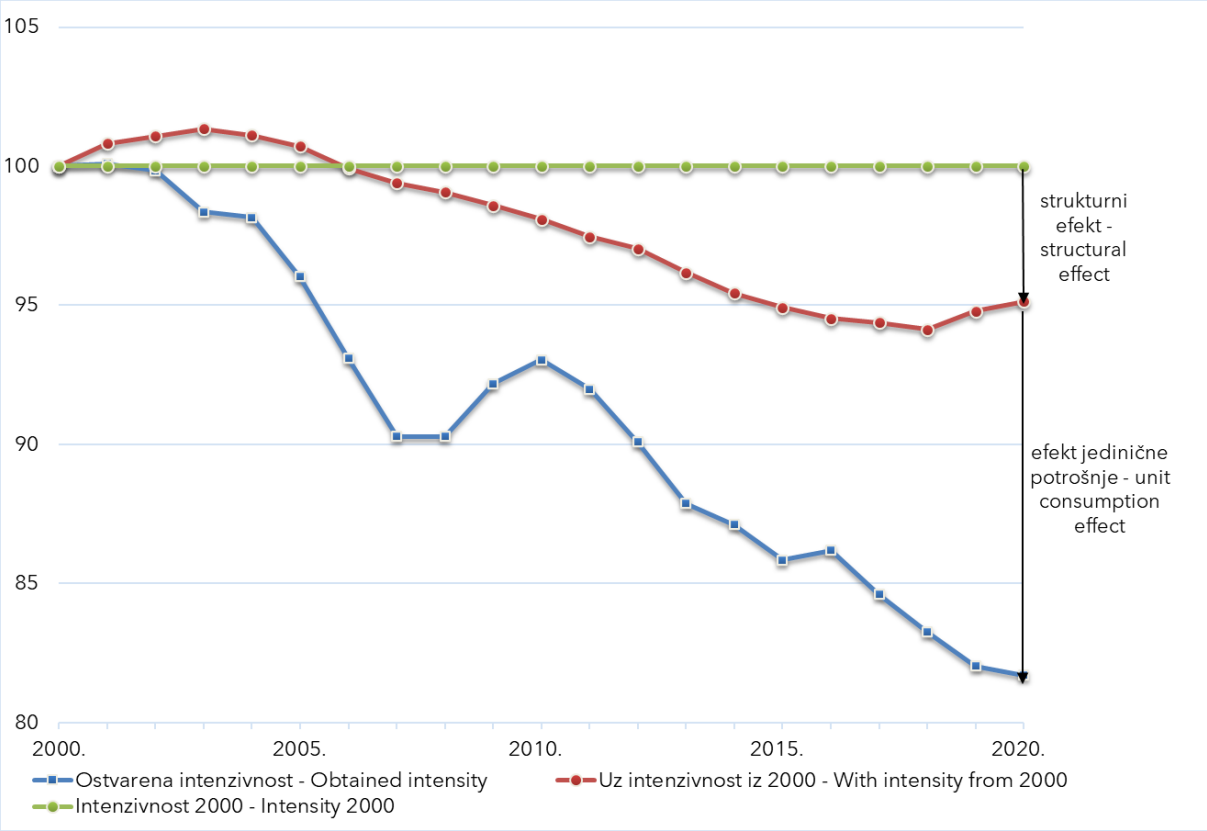


Figure 1.5 Energy intensity and structural macroeconomic effect from 2000 to 2020

Source: EIHP

1.3. Energy efficiency policy and targets

In 2019, Croatia adopted its fourth National Energy Efficiency Action Plan (NEEAP) covering 2019, with an outlook to 2020.

There are several targets established by the NEEAPs:

- primary energy consumption in 2020 will not exceed 448.5 PJ (10.71 Mtoe);
- final energy consumption in 2020 will not exceed 291.3 PJ (6.96 Mtoe);
- according to Article 7 of the Energy Efficiency Directive, the national target for cumulative energy savings has been set to 54.250 PJ for the 2014-2020 period (this latter target is expected to be achieved by a combination of energy efficiency obligation schemes for energy suppliers and alternative measures);

- according to Article 5 of the Energy Efficiency Directive, the national target for annual energy savings (starting with the year 2014) in public buildings is set to 4.89 TJ (0.117 Mtoe).

Using bottom-up methods, it is estimated that the energy efficiency measures proposed in the 4th NEEAP will save 13.65 PJ (0.326 Mtoe) of final energy consumption in 2020. Total energy savings in final consumption, estimated with top-down methods, will reach 35.63 PJ (0.851 Mtoe), while total energy savings in primary energy consumption are estimated to reach 55.26 PJ (1.320 Mtoe), with 76% (42.03 PJ (1.004 Mtoe)) of these savings resulting from savings in final energy consumption and 24% (13.23 PJ (0.316 Mtoe)) of them resulting from energy efficiency measures in energy transformation, transmission and distribution. At the end of 2019, National Energy and Climate Plan (NECP) was adopted, stating new targets and measures for the 2021-2030 period. Energy efficiency obligation schemes will be the most important cross-cutting measure in this forthcoming period.

2. ENERGY EFFICIENCY IN BUILDINGS

2.1. Energy efficiency trends

Building stock at the end of 2019 has been determined following available strategic documents, plans, programs, and new statistical data, and this building stock data is set as the baseline for assessment of stock changes for the period until 2050.

National building stock of existing buildings in Croatia in 2020 comprises 237 315 397 m² of useful building area, out of which 178 592 460 m² are residential buildings and 58 722 937 m² non-residential buildings. Area of permanently inhabited residential buildings in 2020 is determined by Census 2011 data, increased according to statistical information on built and demolished buildings for the period 2011 – 2019, and modelled for 2019 and 2020.

Building energy performance is usually expressed in relation to useful heated area, so useful heated area is determined for both residential and non-residential buildings. The building stock in Croatia is 166 742 024 m² of the useful heated area of the buildings, 76.33% residential and 22.67% non-residential.

Table 2.1 Total useful heated area of the buildings

Building type	Total useful heated area (m²)	Share in total building stock ([%)
Residential buildings	128 930 959	76.33
Single family homes	83 481 377	50.07
Multiapartment buildings	45 449 582	27.26
Non-residential buildings	37 811 064	22.67
TOTAL	**166 742 024**	**100.00**

A series of earthquakes starting with one strong earthquake in Zagreb on 22nd March 2020 with a magnitude of 5.3 and a series of aftershocks determined the pivotal event in the building sector in 2020 in Croatia. Subsequently, an even stronger earthquake with magnitude 6.4 struck Petrinja on 29th December 2020, with devastating consequences for the population. According to „Rapid damage and needs assessment“ in the City of Zagreb, Zagreb, and Krapina-Zagorje County, in all, 18 157 036 m² of buildings were damaged. In all, earthquakes damaged 136 605 buildings, representing 7.6% of the total building stock in Croatia. Petrinja earthquake damaged additional 10 927 buildings that require structural reconstruction. Law on the Reconstruction of Buildings damaged in the earthquake in the City of Zagreb, Zagreb, and

Krapina-Zagorje Counties (Official Gazette, no. 102/20) define manner and procedures for reconstruction or removal of damaged buildings.

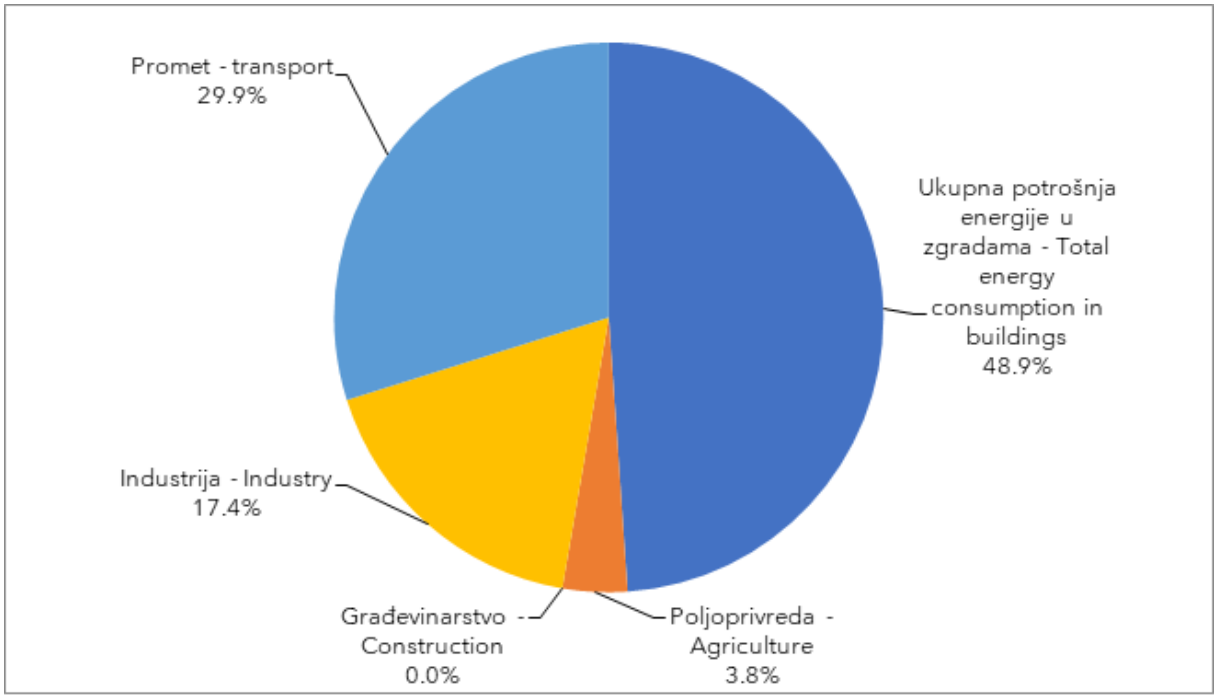


Figure 2.1 Share of total consumption in buildings in 2020 in final energy consumption

The absolute value of energy consumption in buildings in 2020 did not rise much (from 90.30 PJ in 2019 to 93.71 PJ in 2020. However, a significant redistribution occurred as the share of energy consumption in households in 2019 grew from 65.87% to 69.22% in 2020.

2.2. Energy efficiency policies

In Croatia, the first thermal building code was implemented in 2005 and has since been updated and strengthened several times. Minimum energy performance requirements for buildings have been integrated in the Construction Act for new buildings, as well as for major reconstructions of existing buildings, and are dependent on the type of the building. The greatest potential for energy efficiency improvements lies in the existing building stock, as 85% of it was built without building codes.

Therefore, the improvement of the energy performance of buildings is a top priority of the Croatian energy efficiency policy. Four specific programmes for energy renovation of buildings (single family houses, multi-apartment buildings, public buildings and commercial buildings) were adopted by the Government in 2014, covering the period until end of 2020. These programmes are being implemented since then with their own energy saving targets.

The overall target at the building level is the achievement of at least a 50% reduction in thermal energy needs. For each building entering the programme, the annual energy needs for heating prior to renovation are calculated (according to methodology for energy certification of buildings). In order to receive subsidies, the energy renovation of a buildings needs to be designed so that at least 50% reduction of these energy needs for heating are achieved. This 50% is the requirement for each building and is based on the calculated energy demand for heating prior and after the renovation.

The main policy instruments for buildings, beside regulation, are financial programmes, the most utilised of which are those for multi-apartment buildings and public buildings, with the use of the EU Structural Funds.

3. ENERGY EFFICIENCY IN TRANSPORT

3.1. Energy efficiency trends

The transport sector in Croatia is one of the most significant consumers of energy nowadays. The share of transport consumption in final energy consumption is more than 30 percent, which indicates a remarkable potential for energy savings that may be achieved with the implementation of energy efficiency measures.

In the last ten-year period, there has been an almost continuous increase in energy consumption in transport, so that in 2019 the highest consumption in the historical period was recorded (101.84 PJ). In 2020, total consumption was 84.24 PJ.

The annual decline of more than 15 percent is due to the lower need for mobility caused by the COVID-19 global pandemic.

In the structure of transport energy consumption, the largest share, with more than 90 percent, regards road transport.

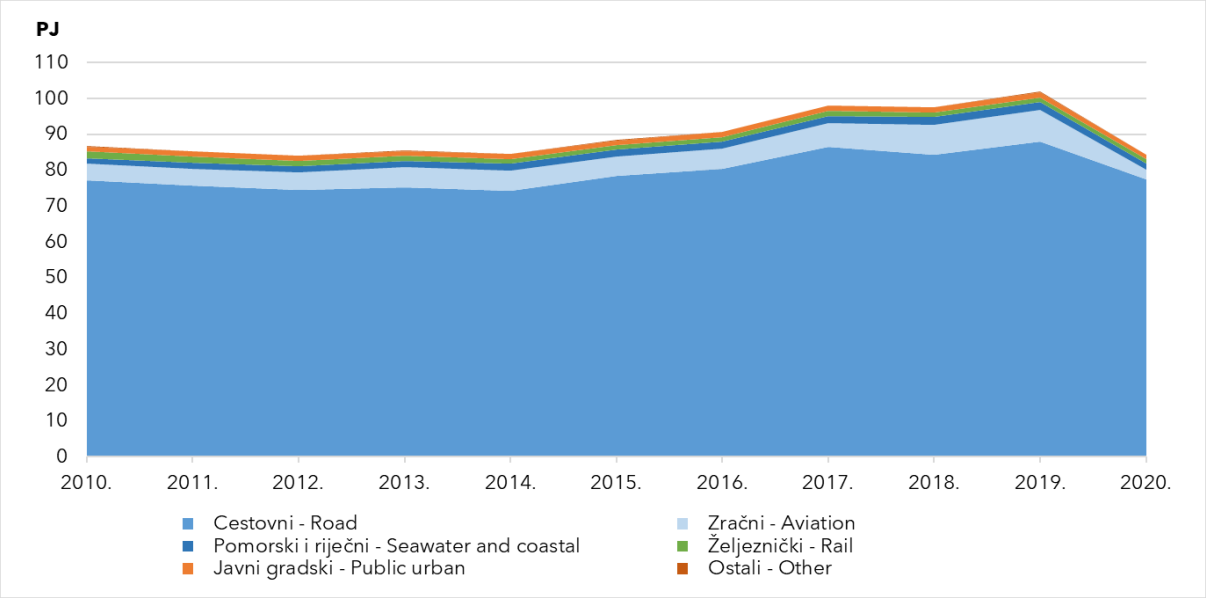


Figure 3.1 Structure of energy consumption in the transport sector

Source: EIHP

Passenger cars consume more than 60 percent of energy in terms of road transport. Consumption of light and heavy-duty vehicles accounts for about 33 percent.

The ten-year trend indicates a continuous increase in the number of registered passenger cars per capita. Given that this trend will continue in the future, the dominant share of passenger cars in the structure of road transport consumption will remain.

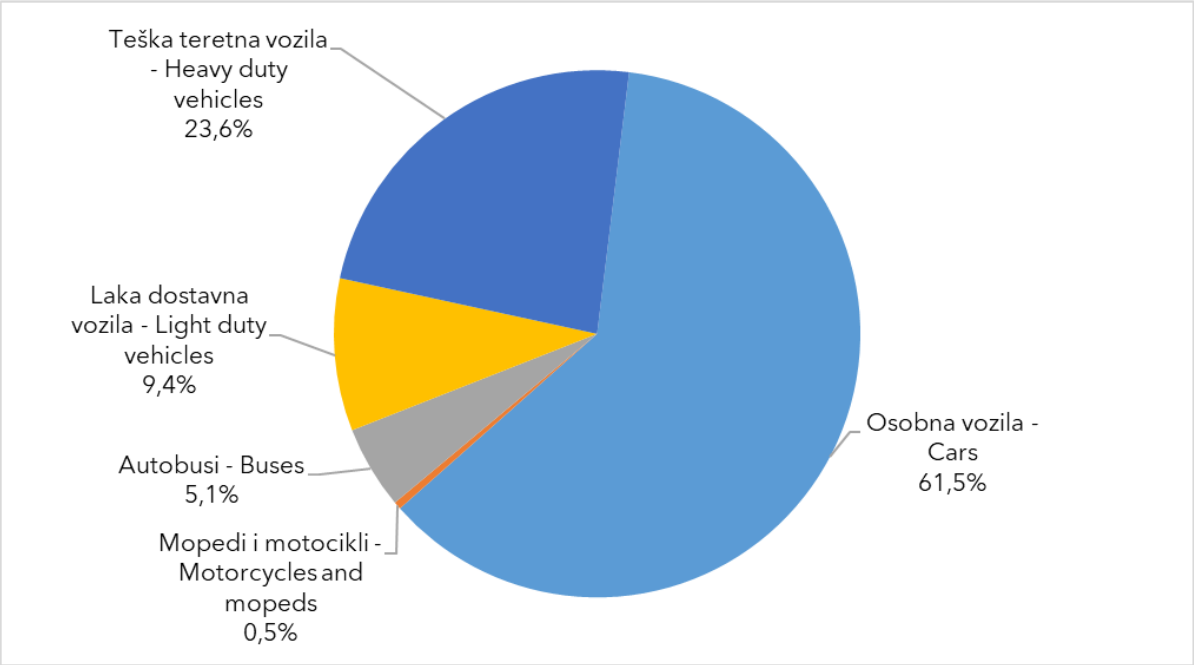


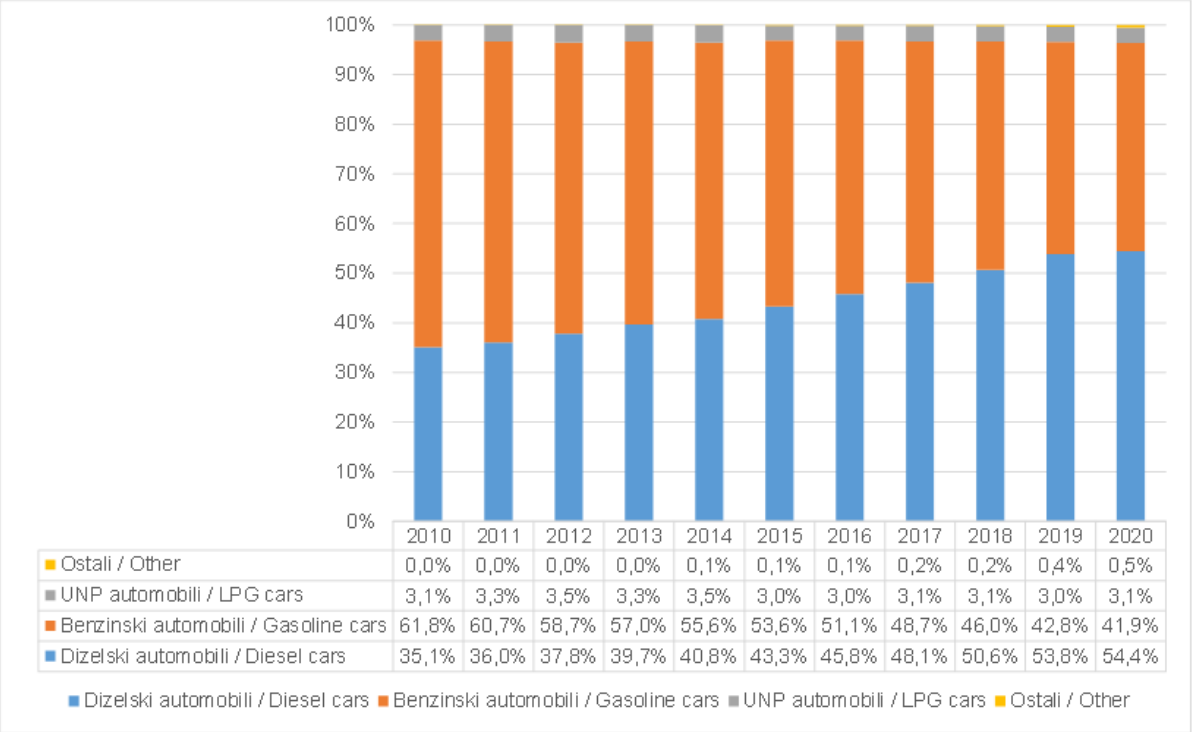
Figure 3.2 The structure of energy consumption in road transport in 2020

Source: EIHP

The structure of passenger cars indicates a clear trend of increasing the share of diesel vehicles, while at the same time, the share of gasoline vehicles is significantly decreasing. The mechanism of structural change is established purely on market-based principles by more favourable prices of diesel fuel on the market over the period, hence without the presence of other incentive measures.

To encourage the development of the alternative fuel vehicles market, in 2014, the Environmental Protection and Energy Efficiency Fund launched the project Driving economically, enabling citizens and companies through grants to purchase more energy-efficient vehicles.

From 2014 to 2020, the procurement of more than 4 500 energy-efficient vehicles (electric, hybrid, and plug-in hybrid) was co-financed. Consequently, there has been an increase in electric and hybrid vehicles in recent years. In 2020, more than 1 300 electric vehicles were registered in Croatia.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Ostali / Other	0,0%	0,0%	0,0%	0,0%	0,1%	0,1%	0,1%	0,2%	0,2%	0,4%	0,5%
UNP automobili / LPG cars	3,1%	3,3%	3,5%	3,3%	3,5%	3,0%	3,0%	3,1%	3,1%	3,0%	3,1%
Benzinski automobili / Gasoline cars	61,8%	60,7%	58,7%	57,0%	55,6%	53,6%	51,1%	48,7%	46,0%	42,8%	41,9%
Dizelski automobili / Diesel cars	35,1%	36,0%	37,8%	39,7%	40,8%	43,3%	45,8%	48,1%	50,6%	53,8%	54,4%

Figure 3.3 Structure of passenger cars by fuel type

Source: EIHP, Ministry of Interior, CVH

The structural change of a passenger and freight transport method is an energy efficiency indicator in the transport sector. For example, a higher share of rail freight transport compared to road transport indicates a higher degree of energy efficiency in freight transport.

Road transport is the primary form of goods and passengers transport concerning the structure of tonne and passenger kilometres in the Republic of Croatia. Consequently, it is vital to implement measures that will result in a modal transition. The modal shift implies the acceleration towards the usage of rail and water transport (on longer routes) and the more notable use of public transport and the so-called active modes (cycling and walking) in urban areas. As rail is still the most energy-efficient solution for medium and long-distance freight, it should become more competitive to road transport. It is achievable by removing operational and technical barriers between national networks and fostering innovations and efficiency. The modal shift should also include inland waterway transport and maritime transport on shorter routes.

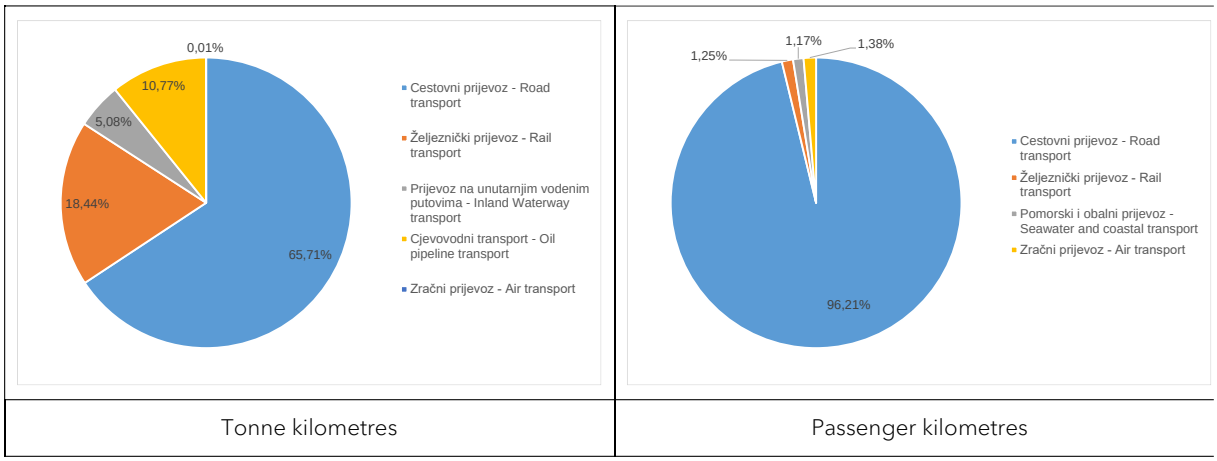


Figure 3.4 Modal structure of tonne and passenger kilometres in 2020

Source: EIHP, CBS

3.2. Energy efficiency policies

In the transport sector, the Croatian energy efficiency policy focuses on the use of alternative fuels and more efficient vehicles. This is mainly done through the fiscal policy (special tax on motor vehicles) as well as financial incentives for more efficient vehicles and for the development of an infrastructure in favour of alternative fuels usage, especially in the field of e-mobility.

4. ENERGY EFFICIENCY IN INDUSTRY

4.1. Energy efficiency trends

The analyses consider the ratio of energy intensity and direct energy consumption to give a representative view of energy efficiency trends in the manufacturing industry. Compared to 2019, the indicators of selected industrial branches are considered. The energy intensity is the ratio of physical energy consumption (all fuels) and the added value within the considered industrial branch.

The largest energy share in manufacturing consumption goes to the non-metallic mineral industry, with a 32% share, where the cement industry has most of the influence. Compared to 2019, there is not a significant change in consumption. Follow the food, beverages, and tobacco industry, with a 15% share, with a significant decrease of -8,4% compared to 2019. The chemical industry follows with a 14 % share in consumption, with a 7,4% increase compared to 2019. The largest increase in energy consumption, about 13%, is present in the wood industry, amounting to a 4% share in the total consumption. A further significant share in energy consumption goes to the wood processing industry, 7,7% with a slight increase, and machinery and metal products, 5,1% share and with a drop of -5,7% compared to 2019. In total, the manufacturing industry has a slight consumption decrease (-0,7%) in comparison to the previous year.

The energy intensity in the industry in 2020, on average has a slight decrease compared to 2019. The highest increase of the energy intensity is in the paper industry, about 5%, and this industry has the highest direct intensity. Further noticeable intensity increase is in the machinery and metal products industry, other industry, and paper and board industry, about 2% each; fabricated metals with 1,4%. Other branches have the intensity decrease. The paper and wood industry have the highest absolute values of energy intensity, with 214 and 108 ktoe/milHRK2000. The average intensity for the industry in total is 74 ktoe/milHRK2000.

The largest drop in energy intensity, almost -28%, is present in the primary metals industry. The wood industry follows with significant -23%, as noted, it has the highest direct intensity. The transport equipment has a -8% decrease, clothing and leather follow with -4%, the chemical industry also -4%. Other individual branches do not have significant changes.

The energy intensity, as the ratio of attained consumption of final energy and added value at constant prices, related to the same ratio for index year 2000, is graphically given in Figure 4.1.

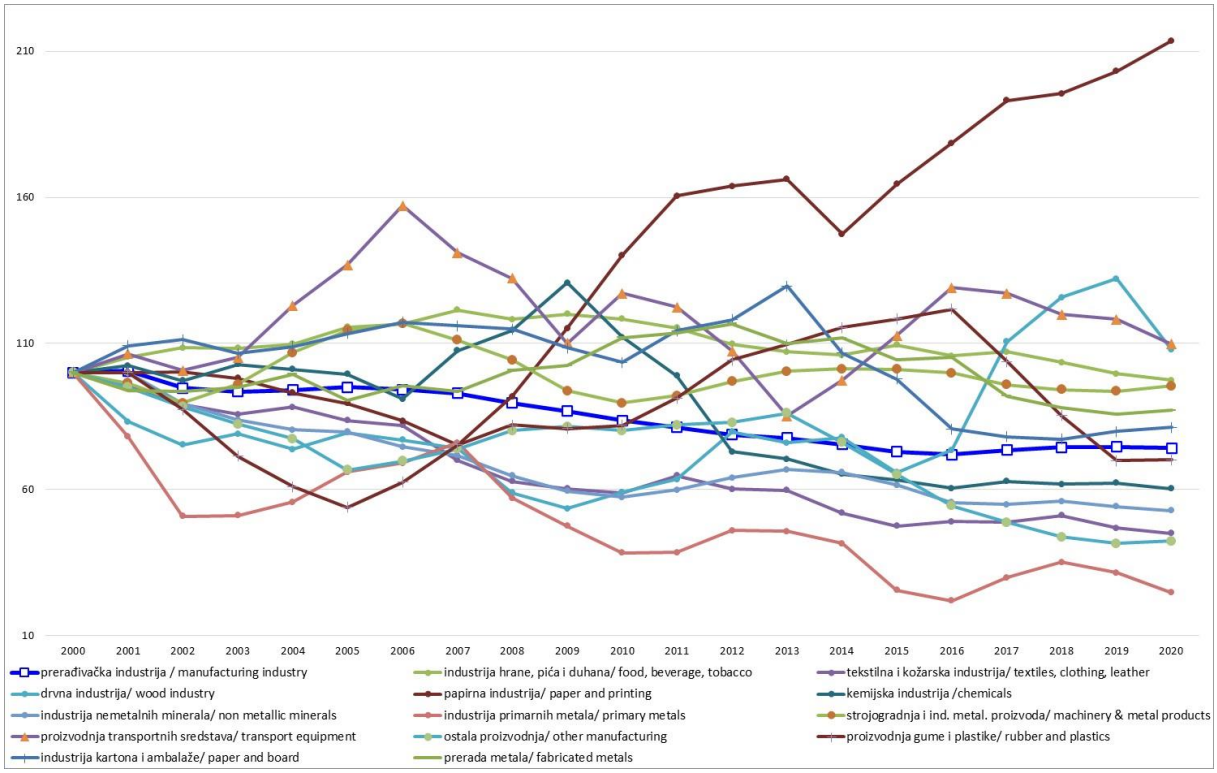


Figure 4.1 Energy intensities of manufacturing industry branches in the period 2000 - 2020

Source: EIHP

The energy efficiency level is presented with the index which is the ratio of total final energy consumption and production index for a considered industrial branch, with the analogue ratio for the index year 2000.

The energy intensity in consumption of manufacturing industries for 2020, in total, does not have significant changes in trend.

The increase of the index, and consequential efficiency drop, is from 2013 significant in the wood industry, and to 2018 it has a 6% increase. That, as in previous regards, is influenced by higher energy consumption. The second highest value of this index is at the paper industry, textiles and other industries group, a bit less than 2% each, while the other branches have less than 1% increase.

The decrease of the energy efficiency index in 2020 is most in the fabricated metals, -15%, transport equipment industry, -7%, and cement industry, -3%. Other industrial branches have no significant changes, compared to the previous year.

Figure 4.2 presents energy efficiency index ODEX for industry for the period 2000 – 2020.

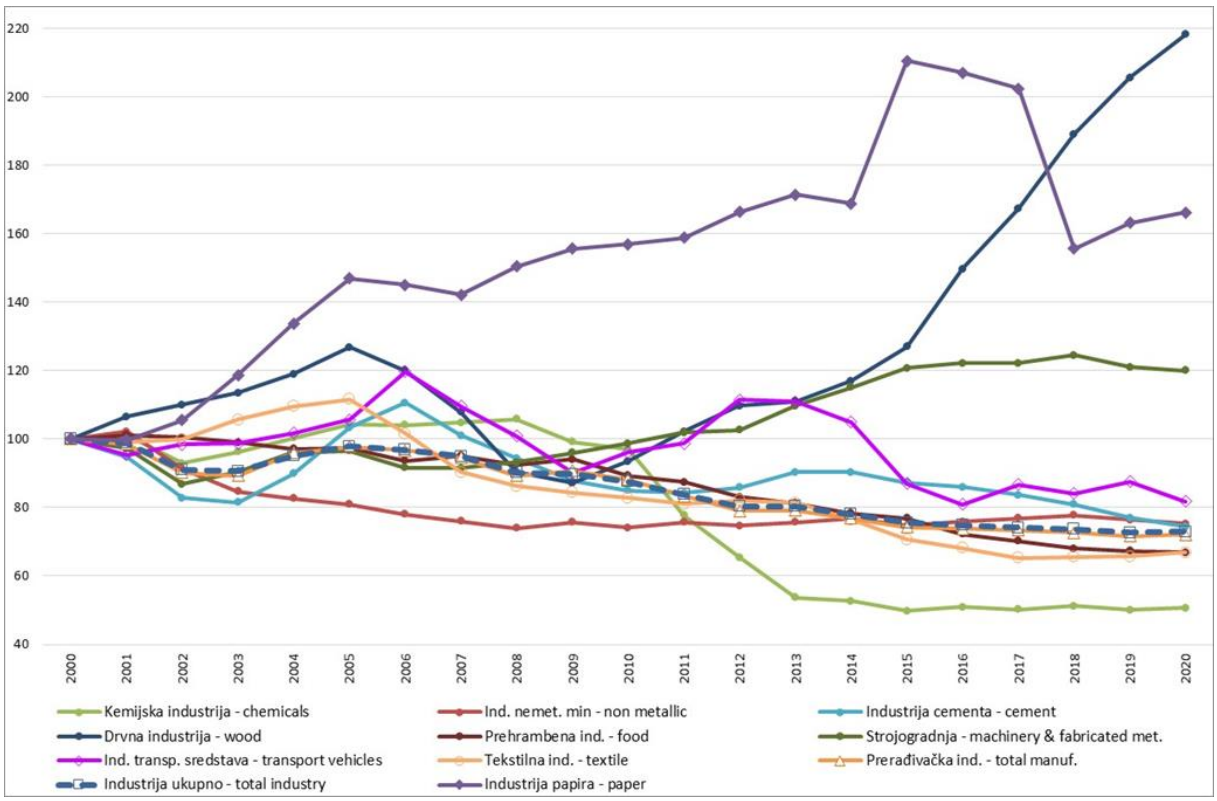


Figure 4.2 Energy efficiency index ODEX for industry for the period 2000 - 2020

Source: EIHP

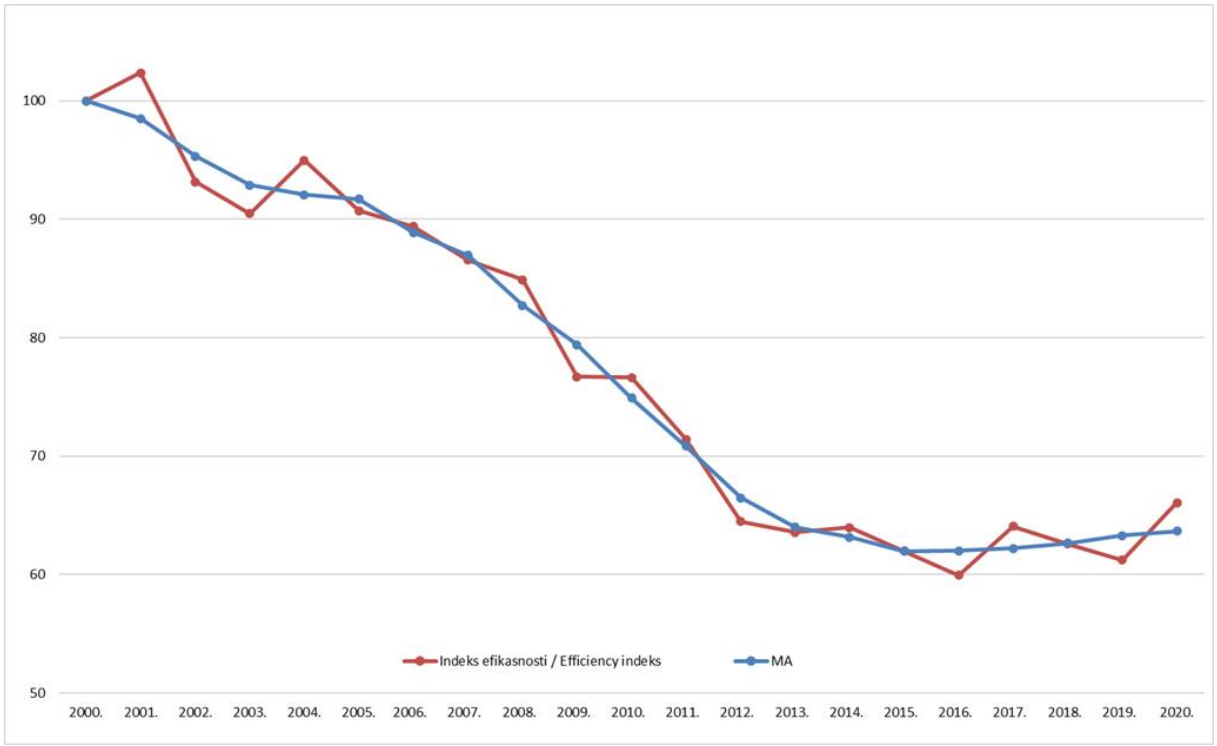


Figure 4.3 Index of energy intensity in industry 2000 - 2020

Source: EIHP

One more indicator of the energy use in industry is the energy intensity index, with the use of gross added value, given in Figure 4.3. This indicator shows the relative ratio between energy consumption (in PJ) and gross value added (in HRK at 2000 level) against the reference year 2000. In Figure 4.3, the red line shows the intensity index itself (marked as efficiency index) and its mean value as the 3-year average (marked as MA).
The energy efficiency trend in the industry, by mean value, was steady during the last seven years. In total, this indicator has no notable variations upon the observed intensity drop until 2014. On the annual level, after a slight decrease, it is rising in the last year. Consequently, the mean value has a small rise in the energy intensity per added value in recent years.

4.2. Energy efficiency policies

The Croatian energy efficiency policy for the industrial sector is focused on regulatory, informational and financial measures. According to the Energy Efficiency Act, all large enterprises are obliged to perform energy audits every five years or, alternatively, to introduce a standardised energy management system based on international norms. A total of €60 millions of funding from the EU Structural Funds has been used since 2017 for stimulating energy efficiency and RES in manufacturing industry.