Energy Efficiency Trends and Policies in Croatia

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Introduction

This report examines data on energy efficiency in Croatia assessing their effectiveness in reducing energy usage, their economic viability, and the potential challenges faced during their adoption. Report seeks to emphasize the importance of ongoing efforts to improve energy efficiency and to explore the best practices that can help guide future initiatives, both at the organizational and governmental levels. Data is presented in three sectors: industry, transport and buildings, and energy efficiency index (ODEX) is also shown. ODEX, the energy efficiency improvement index, is an accepted efficiency indicator in the analysis of energy use. It represents a weighted average of a specific energy consumption index for selected groups of energy consumers.

The results and conclusions of the report are the following:

- Total energy consumption in Croatia in 2023 amounted to 370.2 PJ, which is 3.9 per cent higher than the previous year when it amounted to around 356.2 PJ. At the same time, the real gross domestic product (GDP) growth rate was 1.5 per cent higher than the previous year.
- Energy intensity in the Republic of Croatia in 2023 amounted to 72.9 kgoe / 10^3 US$ 2010 (according to purchasing power parity), 5.4 per cent lower than the average in the European Union (EU 27).
- Final energy consumption in 2023 amounted to 289,9 PJ and increased by 3.1 per cent compared to the previous year (281.1 PJ). In the final energy consumption structure, industry participated with 17.0 per cent (49.1 PJ), transport with 35.9 per cent 104,2 PJ), and other sectors with 47.1 per cent (136.6 PJ).
- The share of renewable energy sources in gross final energy consumption in 2023 is estimated at 28.1 per cent (according to the EUROSTAT methodology), 1.4 percentage points lower than in 2022.
- From 2000 to 2023, there has been a visible decline in the energy efficiency improvement index, i.e., an improvement in energy efficiency for the entire Croatian economy of about 20 per cent. Out of all sectors, industry and households make the most significant contribution to this. In the transport sector, after the previous growth, in 2023 a further decline in the index is visible.

Economic and energy efficiency policies

Economic context

After strong growth in 2021 and 2022, positive economic trends persisted throughout 2023, which is especially noteworthy considering the challenging external conditions and issues with key trading partners. The Croatian economy's faster growth compared to the Eurozone and EU averages signals ongoing economic convergence, with GDP per capita reaching 73% of the EU average in 2022 when adjusted for price differences. Economic activity was fueled by high demand for tourism services, an expansionary fiscal policy, increased EU fund utilization, strong construction activity, and a vibrant real estate market. By the end of 2023, the annual GDP growth rate stood at 4.4%, while the average real GDP growth for the year was 3.1%. Figure 1 shows real growth rate of GDP for the period between 2019 and 2023.

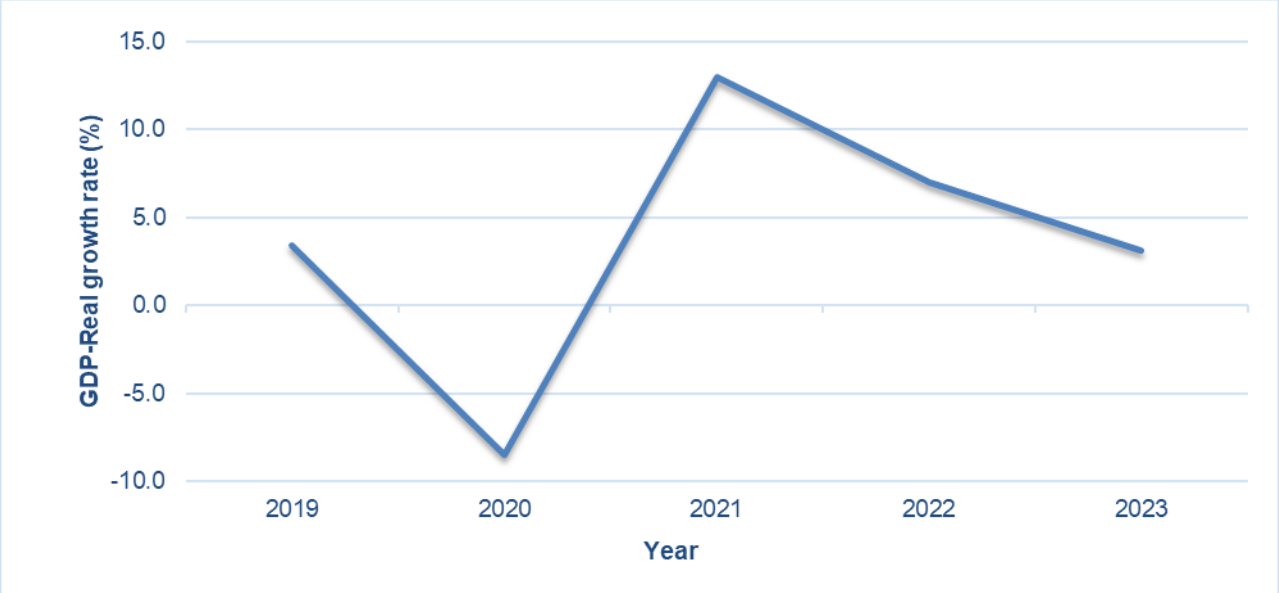

Figure 1 GDP- Real growth rates (%), 2019-2023

The continuation of economic activity growth was influenced by the high demand for services related to tourism, expansionary fiscal policy, increased use of EU funds, intense construction activity, and a dynamic real estate market. All of this contributed to continued positive developments in the labor market, which, along with a reduction in inflation, increased real incomes and boosted consumer optimism, stimulating personal consumption. The year's first half was marked by strong economic growth, supported by almost all components except for merchandise exports, which declined. During the summer months, economic activity slowed, caused by weakening domestic demand and a year-on-year decline in service exports. However, in the fourth quarter of 2023, there

was a renewed recovery in economic activity, primarily due to the strengthening of personal and government consumption, the gradual recovery of merchandise exports, and continued growth in service exports.

The key macroeconomic trends observed in 2023 are as follows:

- Positive economic trends continued throughout 2023, which is particularly important given the challenging external environment and issues with key trading partners. The faster growth of the Croatian economy compared to the average of the Eurozone and the European Union indicates further economic convergence, with GDP per capita reaching 73 per cent of the EU average in 2022 when adjusted for price differences. Economic activity was driven by high demand for tourism services, expansionary fiscal policy, increased use of EU funds, strong construction activity, and a dynamic real estate market;
- The average annual inflation rate in Croatia, measured by the harmonized index of consumer prices (HICP), slowed down to 8.4 per cent in 2023, compared to 10.7 per cent in 2022. An even more significant deceleration was observed when analyzing data from the end of the year, with inflation falling from 12.7 per cent in December 2022 to 5.4 per cent in December 2023. The main reason for this decline was the gradual fading of the effects of significant price increases for numerous products and services during 2022 (base effect) amid a much slower price growth in the current period;
- With Croatia's entry into the Eurozone and the Croatian National Bank (CNB) membership in the Eurosystem, significant changes occurred in the central bank's functioning. The most significant change relates to CNB's participation in formulating and implementing the common monetary policy of the Eurozone. As of January 1st, 2023, the Governor of CNB became a member of the Governing Council of the European Central Bank (ECB), which makes decisions on the common monetary policy, while CNB implements this policy within the Croatian financial system. CNB continues to conduct macroprudential policy, collaborates with the ECB in supervising credit institutions, participates in the Single Resolution Mechanism, and ensures the smooth functioning of the payment system and the supply of cash;
- The average interest rate on newly approved loans to non-financial companies rose significantly, increasing by 220 basis points compared to the end of 2022 reaching 5.4 per cent in December 2023;
- Although total general government debt rose, the debt-to-GDP ratio decreased on an annual basis, driven by real economic growth and ongoing inflationary pressures. Despite a slight decline in the fiscal balance, the robust growth in economic activity and the GDP deflator played a key role in significantly reducing the share of public debt in GDP;

- At the end of 2023, gross external debt amounted to 63.9 billion euros, or 83.7 per cent of GDP, an increase of 14.2 billion euros (10.8 per centage points of GDP) compared to the end of 2022. This growth in gross external debt was mainly due to the increase in the central bank's liabilities, while other domestic sectors recorded a decrease in gross external indebtedness;

Total energy consumption and intensities

Table 1 presents trends in the consumption of energy forms within the total final energy consumption in the period from 2018 to 2023. Figure 2.11.1. shows the same trends for the period from 1990 until 2023. In 2023, the total final energy consumption increased by 3.1 per cent compared to the previous year.

From 2018 to 2023, the final energy consumption increased at an average annual rate of 0.7 per cent.

Table 1 Final energy consumption by fuels

Source: EIHP

	2018	***2019***	***2020***	***2021***	***2022***	***2023***	***2023/22***	***2018-23***
	TJ						***%***	
Coal and Coke	2882	3463	4395	4558	3382	2817	-16.7	-0.5
Petroleum Products	115303	114797	102691	108658	117052	130012	11.1	2.4
Natural Gas	45049	45829	46060	48699	43885	42535	-3.1	-1.1
Renewables and biofuels	48061	48246	49165	53740	45748	43939	-4.0	-1.8
Non-renewable waste	818	1129	1630	1892	1935	2070	7.0	20.4
Steam and Hot Water	9454	10015	10597	11442	10607	9813	-7.5	0.7
Electricity	57921	57862	54474	59054	58481	58730	0.4	0.3
TOTAL	**279489**	**281341**	**269012**	**288043**	**281090**	**289915**	**3.1**	**0.7**

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/m^2, 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.

An ODEX value of 90 indicates a 10 percent improvement in energy efficiency. ODEX is made up of two components: the aggregate index and the technical index. The aggregate index accounts for factors unrelated to energy efficiency, such as climate variations, changes in economic and industrial structures, and shifts in lifestyle (e.g., larger dwellings). The technical index focuses specifically on energy efficiency. The year 2000 serves as the reference year for the index.

From 2000 to 2023, there has been a noticeable decline in the energy efficiency improvement index, reflecting an overall energy efficiency gain of approximately 20 percent for the Croatian economy. Industry and households have made the largest contributions to this improvement. Additionally, after a period of growth, the transport sector index showed a decline in 2023. Figure 9.1.1 illustrates the ODEX trends for various sectors of direct energy consumption. Figure 2 shows the direction of ODEX for individual sectors of direct energy consumption.

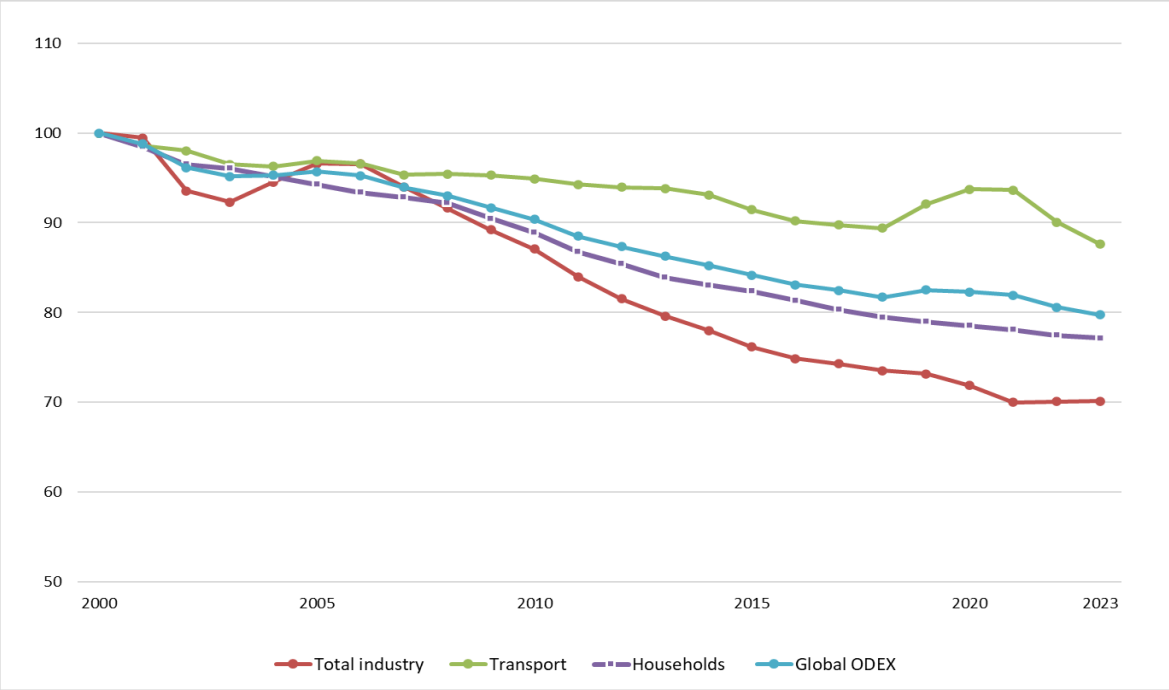

Figure 2 Energy efficiency index ODEX, 2000 – 2023

Source: EIHP

The energy consumption efficiency in individual sectors is monitored further by observing the energy intensity related to economic indicators. Energy intensity is determined as the ratio of total energy consumption in a particular sub-sector and the gross added value realized within that sub-sector for the observed year.

Figure 3 presents the trend of energy intensities for individual sectors of direct energy consumption from 2000 to 2023. In 2023, the trends from the previous period for all sectors are continuing, except for construction and, less notable, for transport.

Considering all sectors together, the energy intensity index and the energy intensity trend continue with a slight decline, compared with the previous year, with a value of less than 1 per cent compared to last year.

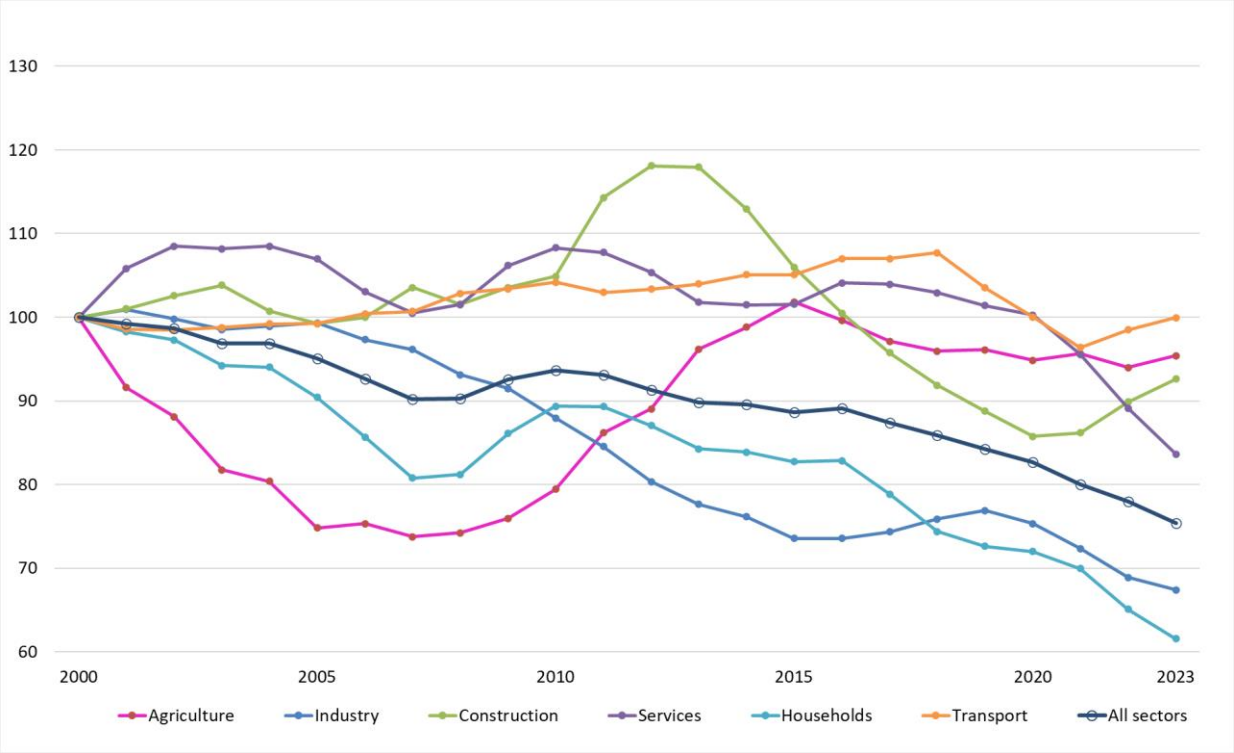

Figure 3 Energy efficiency index ODEX, 2000 – 2023

Source: EIHP

Primary and final energy intensity are the further efficiency indices. This quantity is derived through the total energy consumption and gross domestic product ratio or direct (final) energy consumption and gross domestic product.

The primary to final energy intensity ratios from 2000 to 2023 are given graphically in Figure 4 Compared to the previous year, the intensity of primary energy consumption maintains the same downward trend, only with a slightly smaller gradient. The intensity of final consumption also has such a movement.

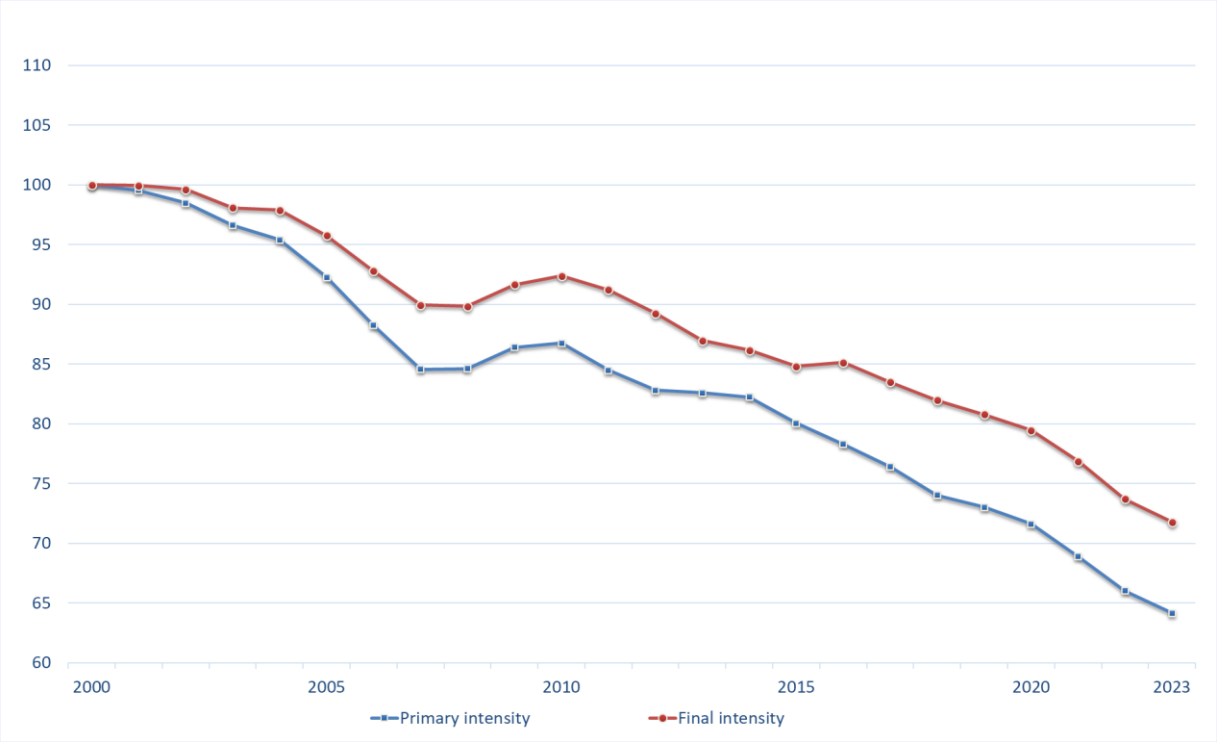

Figure 4 Primary to final energy intensity ratio from 2000 to 2023

Source: EIHP

Energy intensities and the resulting indicators are commonly used in energy efficiency analyses. Additional indicators are derived by examining changes in energy consumption per unit of product or service, as well as changes in performance related to the market value of the product or service. The indices generated in this way are influenced by structural factors and variations in unit consumption.

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 result of the unit energy consumption effect, which is an indicator of energy efficiency.

Figure 5 presents the energy intensity indicator and the influence of the structural macroeconomic effect until 2023. By 2014, structural changes had a significant effect on reducing energy intensity. The impact of lowering unit energy consumption on the remaining energy intensity reduction is more important. Variations in the effect of unit consumption are significant in the period up to 2010, while after that, the downward trend is more continuous. Compared to the previous year, both the structural effect and the effect of unit consumption have a continued decline in the index.

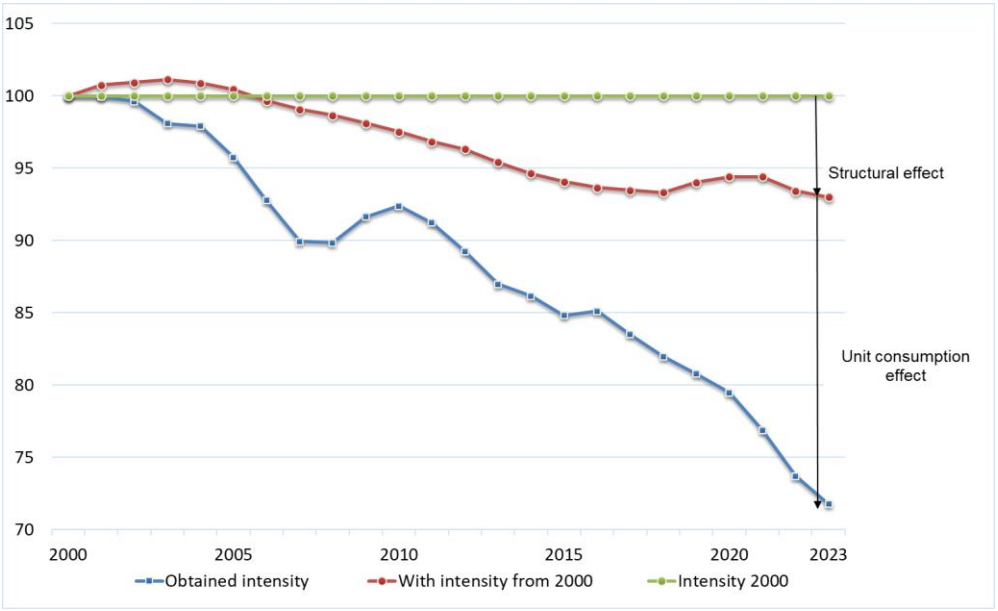

Figure 5 Energy intensity and structural macroeconomic effect from 2000 to 2023

Energy efficiency policy and targets

The national energy efficiency increase targets until 2020 and 2030 are defined in the Energy Efficiency Act. The 2030 targets are based on the first version of the NECP and are further set out in the National Energy Efficiency Action Plan (NEEAPEnU) for 2022-2024. The targets are expressed as the absolute amount of final energy consumption in 2030, which should amount to 286.9 PJ (6.85 Mtoe) or primary energy in 2030 344.4 PJ (8.23 Mtoe). The targets expressed as the absolute amount of primary and final energy consumption are shown in Figure 6.

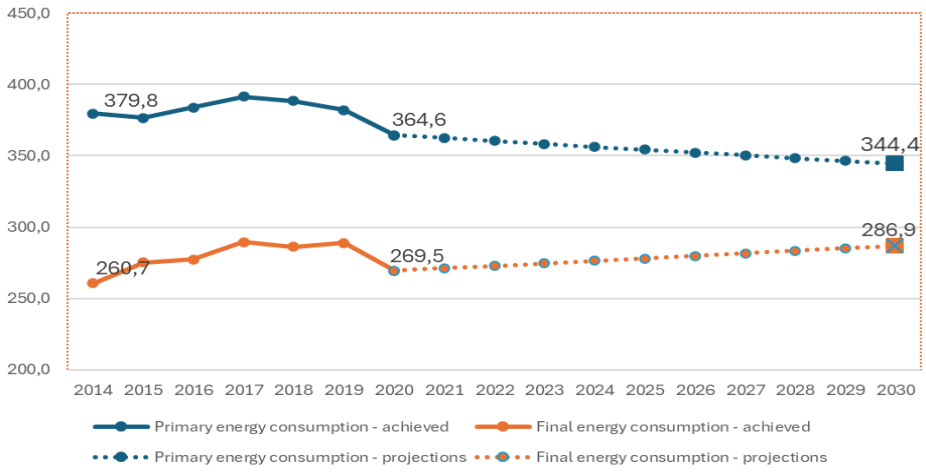

Figure 6 Indicative trend of achieving energy consumption from 2014 to 2020 and consumption projections from 2021 to 2030 with existing measures

In addition to regulatory measures, other energy efficiency measures are being implemented in Croatia, according to three-year national action plans. The last NAPEnU was prepared for the period from 2022 to 2024. These are mainly measures of financial incentives through grant mechanisms or financial instruments from national sources (the Environmental Protection and Energy Efficiency Fund) and EU sources (Recovery and Resilience Mechanism (MOO); funds are used under the National Recovery and Resilience Plan (NPRR); European Regional Development Fund (ERDF)).

Overall energy efficiency progress and policies

This chapter analyzes Croatia's energy efficiency progress and related policies. It examines energy consumption trends across sectors (industry, transport, households/services/agriculture) from 2017-2023 as well as energy savings.

Energy consumption based on ODYSSEE

Croatia's final energy consumption between 2017 and 2023 remained relatively stable, fluctuating between 6.43 and 6.89 Mtoe, with a peak in 2021 and a low in 2020, likely due to the COVID-19 pandemic. The household, services, and agriculture sector consistently dominated consumption, averaging around 3.38 Mtoe annually, followed by transport, which showed a gradual increase post-2020. Industry consumed the least energy and exhibited a slight downward trend in recent years.

Table 2 Final energy consumption

Mtoe	2017	2018	2019	2020	2021	2022	2023
Final consumption of industry	1.15	1.16	1.17	1.17	1.19	1.13	1.10
Final consumption of transport	2.20	2.15	2.24	1.97	2.15	2.24	2.36
Final consumption of households, services and agriculture	3.44	3.37	3.31	3.29	3.54	3.35	3.36
Total final consumption	**6.79**	**6.68**	**6.73**	**6.43**	**6.89**	**6.72**	**6.81**

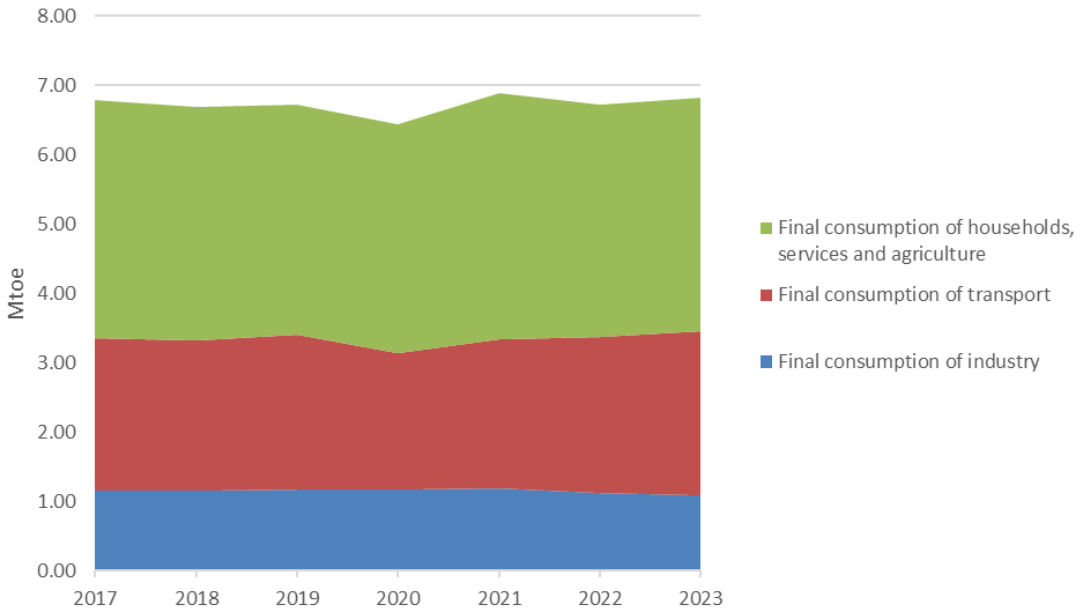

Figure 7 Final energy consumption

Energy Savings

Energy savings, representing reductions in energy use achieved through energy efficiency efforts, are the focus of this chapter. Croatia's progress in realizing these savings between 2017 and 2023 is analyzed, utilizing the provided consumption data. Energy saved within key sectors, including

industry, transport, households and services, is examined. Through this analysis, the effectiveness of implemented energy efficiency measures is assessed, and potential opportunities for future improvements are identified.

Croatia's energy savings, measured in Mtoe since 2000, show a positive upward trend from 1.35 Mtoe in 2017 to 1.58 Mtoe in 2023, indicating increasing effectiveness of long-term energy efficiency efforts. The household sector leads in savings, growing from 0.63 to 0.71 Mtoe, followed by industry, which saw savings rise from 0.54 to 0.66 Mtoe, particularly after 2021. While transport savings increased slightly from 0.14 to 0.16 Mtoe, and services remained stable at 0.05 Mtoe, these sectors demonstrate potential for further improvement.

Table 3 Energy savings

Mtoe	2017	2018	2019	2020	2021	2022	2023
Energy savings from industry since 2000	0.54	0.54	0.54	0.55	0.58	0.66	0.66
Energy savings from transport since 2000	0.14	0.14	0.15	0.15	0.15	0.15	0.16
Energy savings from services since 2000	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Energy savings from households since 2000	0.63	0.64	0.66	0.67	0.68	0.70	0.71
Energy savings from final consumers since 2000	**1.35**	**1.37**	**1.39**	**1.42**	**1.46**	**1.55**	**1.58**

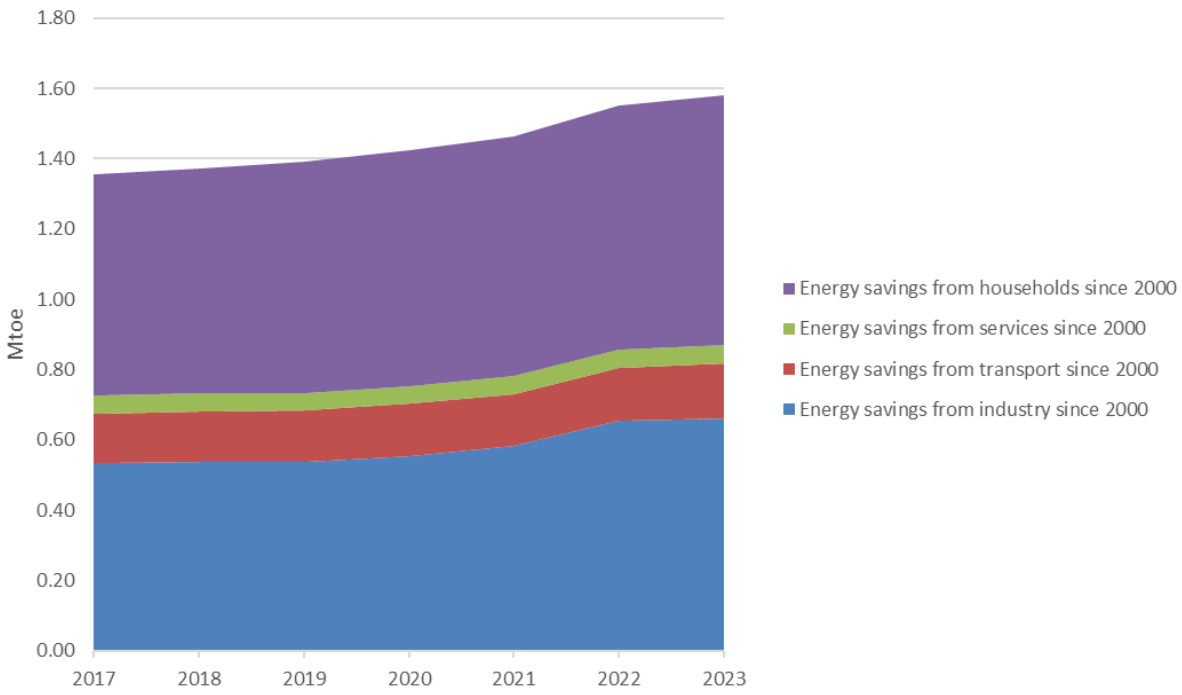

Figure 8 Energy savings

Comparison with other countries

This chapter presents the Overall Energy Efficiency Score, comparing Croatia's performance with that of other countries.

Overall Energy Efficiency Score within the context of the Odyssee-Mure project is a composite indicator, meaning it's built from multiple sub-components to give a broader picture. In this case, it's designed to reflect a country's overall performance in energy efficiency.

Overall Energy Efficiency Score is the headline number, the single metric used to represent how well a country is doing in energy efficiency. It's not a direct measurement of energy consumption or savings. Instead, it's a calculated score based on other indicators.

The overall score is calculated as a simple average of three sub-scores:

- **Energy Efficiency Level**: This score reflects the current state of energy efficiency in a country. A higher score indicates better current performance. It likely considers factors like the energy intensity of the economy (how much energy is used per unit of GDP), the efficiency of buildings, transport, and industry, etc. Odyssee-Mure likely has its own specific methodology for calculating this "level" score.
- **Energy Efficiency Progress**: This score measures how much a country has improved its energy efficiency over a specific period. It's a dynamic measure, showing the rate of change. A higher score here means the country is making significant strides in improving energy efficiency. Again, Odyssee-Mure will have its own way of quantifying this progress.
- **Energy Efficiency Policies**: This score evaluates the quality and effectiveness of a country's energy efficiency policies. It's more qualitative than the other two, likely considering things like the existence of strong regulations, incentives for energy efficiency investments, public awareness campaigns, and other policy instruments. It might involve expert assessments or evaluations of policy effectiveness.

Each of the three sub-scores contributes equally to the overall score. No one component is considered more important than the others. This equal weighting implies that a country needs to perform well across all three areas (current level, progress, and policies) to achieve a high overall score.

Croatia, with a score of 0.28, finds itself near the bottom of the Overall Energy Efficiency rankings, holding the second-lowest position just ahead of Malta. This low standing indicates considerable room for improvement in energy efficiency within Croatia.

Comparing Croatia to other nations reveals that neighboring countries like Slovenia (0.51) and Hungary (0.47) achieve significantly better results as shown on Figure 9.

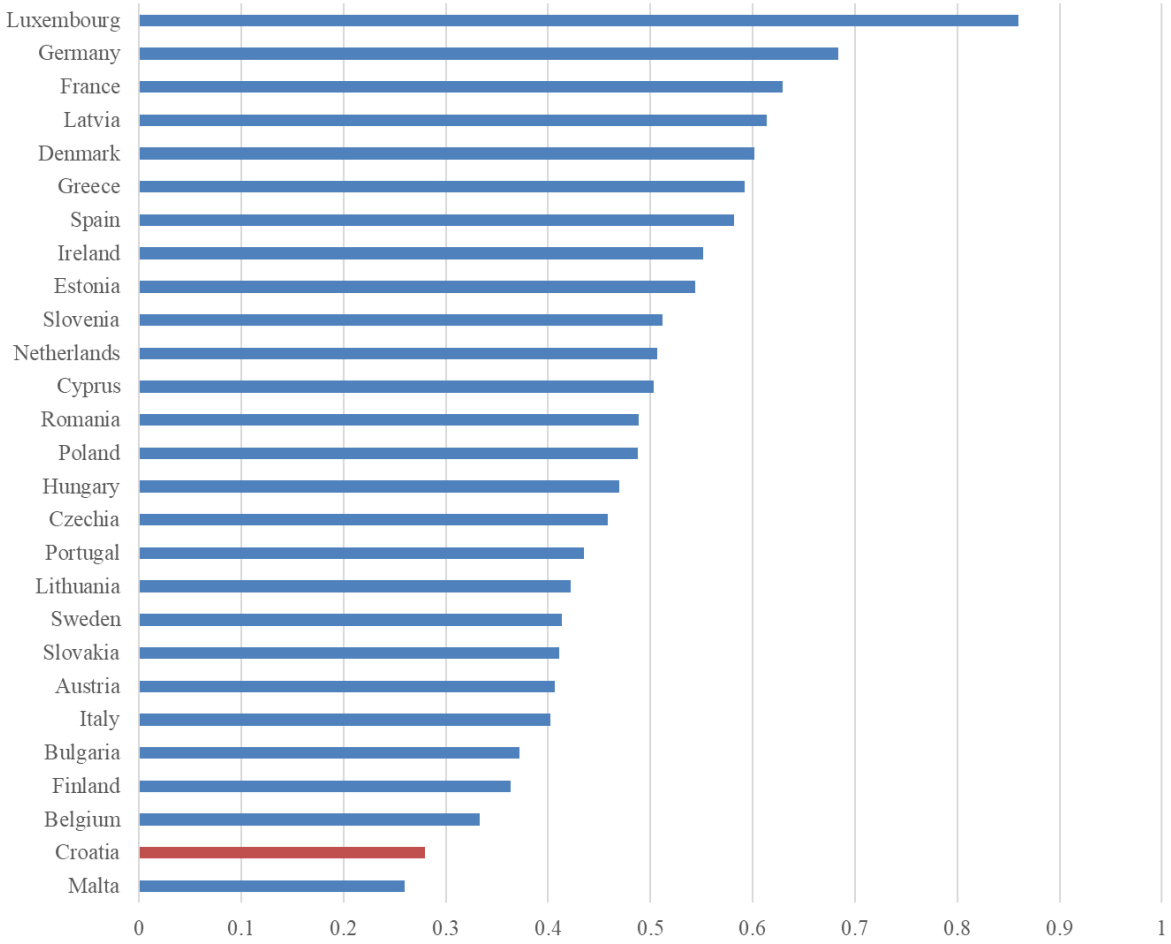

Figure 9 Overall Energy Efficiency Score

Sectoral energy efficiency trends and policies

Building sector

Energy efficiency trends

The national building stock of the Republic of Croatia in 2023 was enlarged in 2023 compared to 2022 by 1.603.974 m^2 of building area. The non-residential buildings area increased by 167.894 m^2, the single-family homes area by 919.366 m^2, and apartments in multi-residential and non-residential buildings by 515.714 m^2.

The building stock in the Republic of Croatia in 2023 amounts to 174.368.188 m^2 of useful heated area, of which 76.79 per cent are residential buildings and 23.21 per cent are non-residential buildings (Table 4). The implementation of the building energy renovation program continued, using funds from the National Recovery and Resilience Plan. The Ministry of Spatial Planning, Construction and State Property launched the portal https://obnavljamo.hr/ to better inform citizens about energy renovation and the possibilities of co-financing.

Table 4 Total useful heated area of the buildings

Building type	Total useful heated area [m^2]	Share in total building stock [%]
Residential buildings	133,902,827	76.79
Single family buildings	85,783,138	49.20
Multiapartment buildings	48,119,689	27.60
Non-residential buildings	40,465,361	23.21
TOTAL	**174,368,188**	100

In 2023, there was a decrease in total energy consumption in households and the service sector. When we look at the share of total energy consumption in buildings in total final consumption, it amounts to 43.2 per cent, as shown in Figure 10.

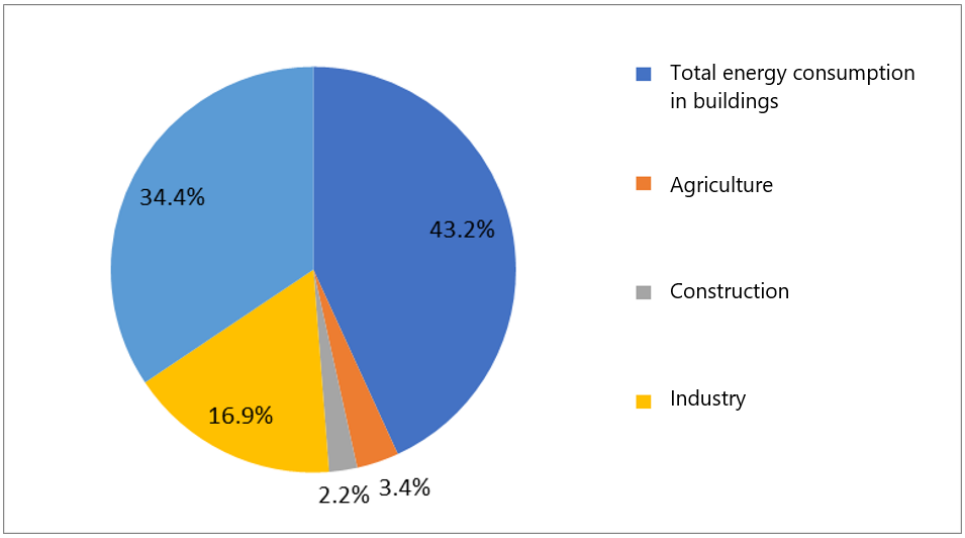

Figure 10 Share of total consumption in buildings in 2023 in final energy consumption

Energy efficiency policies

The expected impact of a group of measures to promote energy efficiency and transport is equivalent to a reduction in immediate energy consumption in projections for the scenario with additional measures compared to the scenario with the existing measures, which amounts to 17.61 PJ in 2030.

Some of the planned policies, measures and programs for the achievement of the national target of increasing energy efficiency by 2030 in Croatia are following:

- **Energy renovation program for apartment buildings** – Several categories of renovation are foreseen (integral energy renovation, in-depth renovation, comprehensive renovation) and three implementation models (renovation of apartment buildings not damaged in the earthquake, renovation of apartment buildings damaged in the earthquake, financial support for citizens at risk of energy poverty). It is necessary to encourage the restoration to the nZEB standard more strongly. In addition, it is necessary to consider establishing a special fund from which the costs will be reimbursed to energy-poor households or households at risk of energy poverty to remove the obstacle to securing a sufficient number of co-owners consent for energy renovation.
- **Energy renovation programme for family houses** – The programme needs to be conceptualised as a continuation of the implementation of the Energy Efficiency Programme for single-family homes from 2014 to 2020, with co-financing from the Environmental Protection and Energy Efficiency Fund. It is necessary to ensure the continued implementation of the renovation of family homes by renewing public calls for grants every year for 2021-2030. The primary sources of co-financing should be revenues from the sale of emission

units from the EU ETS and revenues from fees paid by suppliers in the energy efficiency obligation system in case of non-fulfilment of their obligations.

- **Energy renovation programme for public sector buildings** – The measure represents the continuation of implementing the Program for Energy Renovation of Public Sector Buildings from 2016 to 2020. The Government of the Republic of Croatia adopted the Energy Renovation Program for the Public Sector up to 2030 („Official Gazette", No. 41/22). The NPRR and the PCC have provided funds for the period up to the end of 2026 for 2021-2027 (with implementation until 2030) to ensure the activation of private capital and the ESCO market, especially for buildings that are suitable for such financing models (buildings with continuous operation, such as hospitals, prisons, homes for the elderly, etc.) and which belong to the category of central government buildings, for which there is a binding renovation goal defined in Energy Efficiency Directive 2012/27/EU.
- **Energy renovation programme for buildings that have the status of a cultural property** – Protected buildings within the meaning of this Programme can be classified into two categories: Individually protected cultural property (individual buildings and building complexes) and Buildings within a protected cultural and historical unit. The programme does not cover buildings protected as preventively protected cultural or registered cultural property. The programme has this programme: a holistic (integral) approach and an approach with the application of individual developed two basic approaches to the energy renovation of buildings, which are the subject of energy renovation measures.

Industry sector

Energy efficiency trends

The non-metallic mineral industry holds the largest share of energy consumption in manufacturing, accounting for 37%, with the cement sector being the most influential. This represents a 5% increase compared to the previous year. The food, beverage, and tobacco industry follows with a 16.4% share, but it saw a 5% decrease from the previous year. The wood and wood products sector comes next, with an 8% share, showing a 7% decrease compared to last year. The chemical industry experienced the most significant rise in energy consumption, up by approximately 16.5%, and holds about 6% of the total consumption. Overall, the manufacturing industry saw a 2.4% increase in energy consumption compared to the previous year.

The energy intensity index for the industry in 2023 has an average increase of almost 7 per cent compared to the previous year. The most significant growth of this indicator is present in the chemical industry, more than 31 per cent, and the paper industry, more than 24 per cent, where the value of this index is the highest. A further significant increase of this index is present in non-metallic minerals, then cardboard and other paper products, in more than 20 per cent of these groups.

Machinery production, other industries, production of primary metals, and rubber and plastics industry also significantly increase this index.

The most significant decrease in the energy intensity index, notable 43 per cent, is in the production of transport equipment. With almost a 25 per cent drop, it is followed by the textile and leather industry, followed by the wood industry, which has a nearly 19 per cent drop. The food and beverages industry also experienced a notable decrease in the energy intensity index compared to the previous year, around 15 per cent. A graphic presentation of energy intensity trends in 2023, regarded as a ratio of final energy consumption and added value at constant prices to the index year 2000, is given in Figure 11.

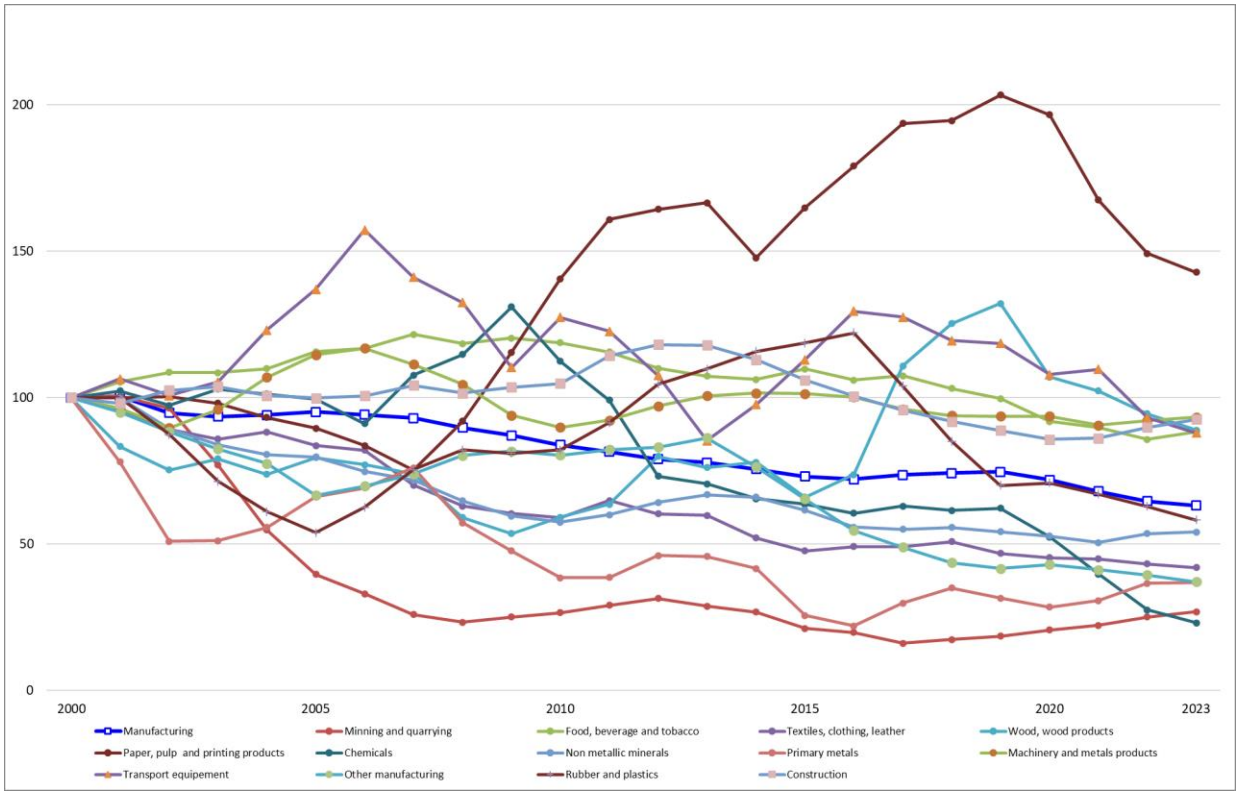

Figure 11 Energy intensities of manufacturing industry branches in the period 2000 – 2023

The energy efficiency level is presented with the index, which is the ratio of total final energy consumption and production index for a regarded industrial branch, concerning the analogue ratio for the index year 2000. The total energy intensity in consumption in manufacturing industries for 2023 doesn't show significant changes in trend.

The index increase and consequential efficiency drop are continuously present in the wood industry, with an increase of about 2 per cent compared to 2022 due to higher energy consumption. The non-metallic minerals industry (as previously observed, primarily due to the cement works) and food and beverages industry have a slight increase in this index. At the same time, the decrease is present in other industrial branches. The most significant drop compared to the previous year is in

the chemical industry, about -30 per cent, and in the production of transport means, over 20 per cent.

Energy efficiency index ODEX for industry for 2023 is presented in the Figure 12.

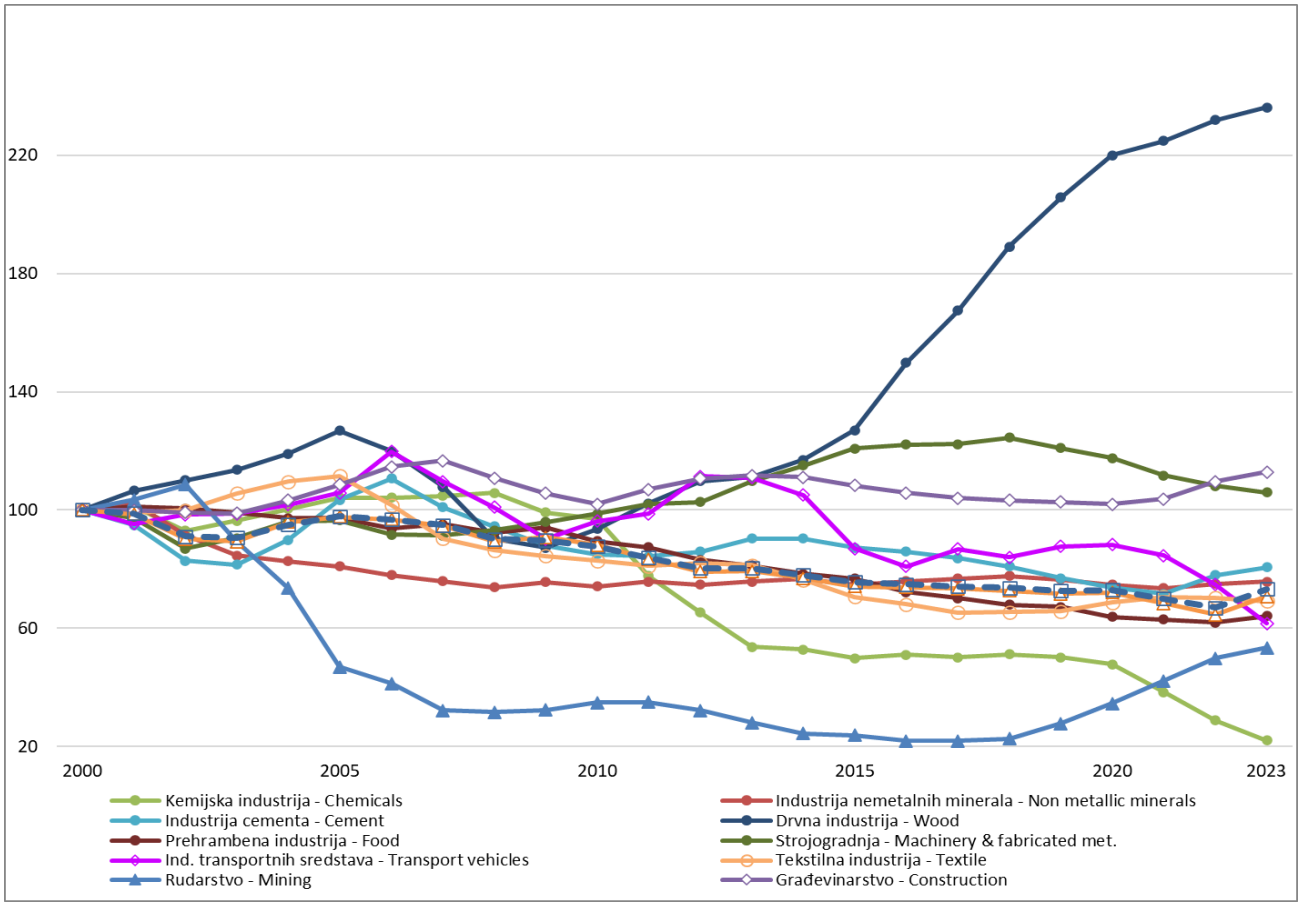

Figure 12 Energy efficiency index ODEX for industry for the period 2000 – 2023

Another indicator of energy use in industry is the energy intensity index, with the use of gross added value, given in Figure 9.3.3. This indicator shows the relative ratio between energy consumption (in PJ) and gross value added (in EUR at 2000 level) against the reference year 2000. In Figure 13, the red line shows the intensity index (marked as the efficiency index) and its mean value as the three-year average (marked as MA).

The energy intensity trend in the industry towards the mean value has not changed significantly in recent years, with very little growth in the last year. In terms of annual values, rapid changes have been visible in recent years, while in 2023, this index has no changes. Factors that cause variations are the reduction of specific energy consumption per product unit, i.e. the increase of energy efficiency, occasional economic difficulties, results in increasing the market value of production, and structural changes in the industry.

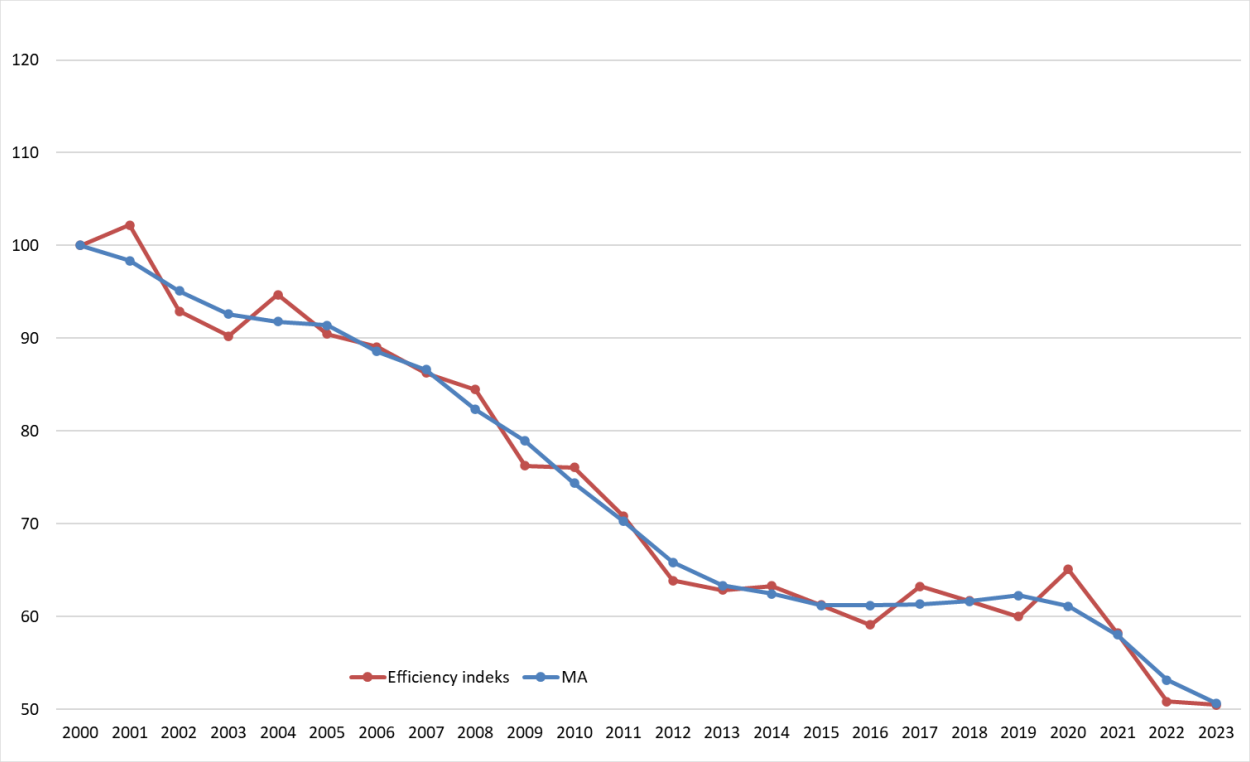

Figure 13 Index of energy intensity in industry 2000 – 2023

Energy efficiency policies

Croatia's energy efficiency policy for the industrial sector emphasizes regulatory, informational, and financial measures. Under the Energy Efficiency Act, large enterprises are required to conduct energy audits every five years or, as an alternative, implement a standardized energy management system based on international standards.

One of the policies/measures for achieving national targets regarding increase in energy efficiency by 2030 in Croatia:

- EUR 60 million was secured from the EU Funds in the past period, based on the OPCC. The absorption of funds was excellent, which proves that industrial plants in the Republic of Croatia have significant potential for improving energy efficiency, reducing energy consumption and reducing the share of conventional (fossil) fuels in total energy consumption by introducing renewable energy sources. This measure aims to ensure the continuation of co-financing of implementing such measures in manufacturing industries through grants and financial instruments.

Transport sector

Energy efficiency trends

The transportation sector is one of Croatia's largest energy consumers, making up over 37 per cent of total final energy consumption. Over the past decade, energy usage in this sector has shown a nearly consistent upward trend. A significant drop of more than 15 per cent in energy consumption occurred between 2019 and 2020, primarily due to reduced mobility during the global COVID-19 pandemic.

However, as the economy recovered in 2021, energy consumption rebounded to 94.2 PJ. This upward trend continued into 2022, with consumption reaching a record high of 112.5 PJ in 2023. Road transport dominates the energy consumption profile within the sector, accounting for nearly 90 per cent of the total.

Figure 14 shows a structure of energy consumption in the transport sector.

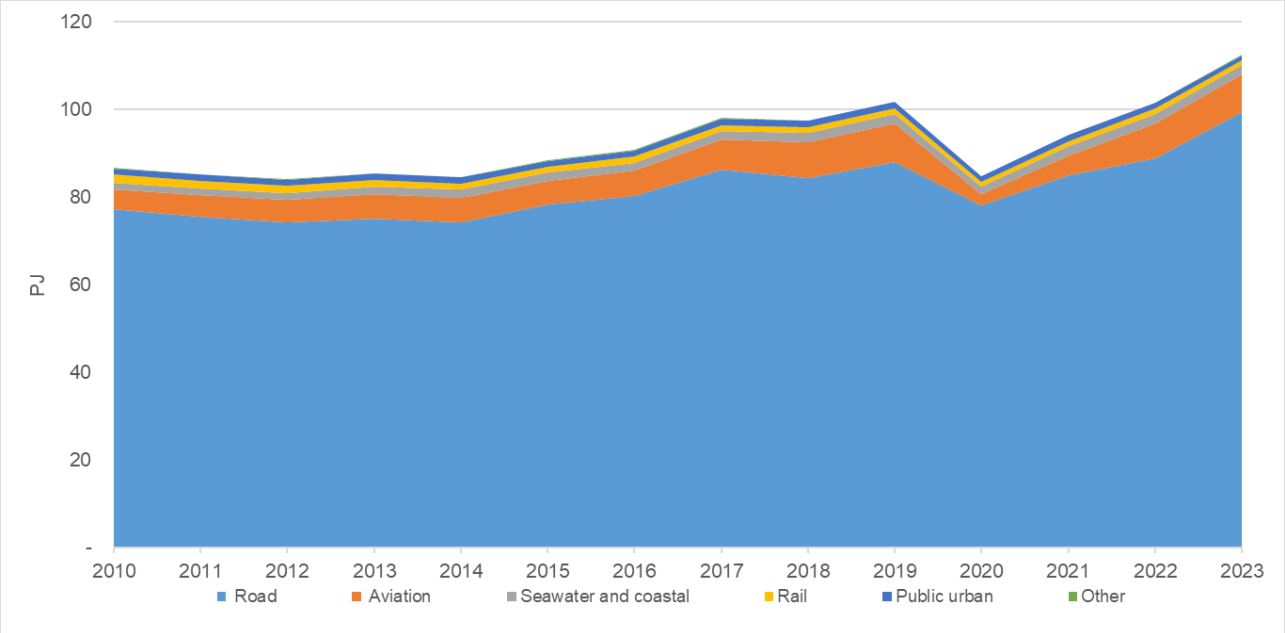

Figure 14 Structure of energy consumption in the transport sector

Structurally, passenger vehicles account for over 65 per cent of energy consumption within road transport, while light and heavy-duty vehicles represent approximately 30 per cent. A ten-year trend indicates a steady increase in registered passenger vehicles per capita. Given that this trend is expected to continue, the dominant share of passenger vehicles in the energy consumption structure of road transport is likely to persist.

The composition of passenger vehicles reveals a clear trend of increasing diesel-powered vehicles while the share of gasoline-powered vehicles has steadily declined. This structural shift is driven entirely by market dynamics without the implementation of specific incentive measures.

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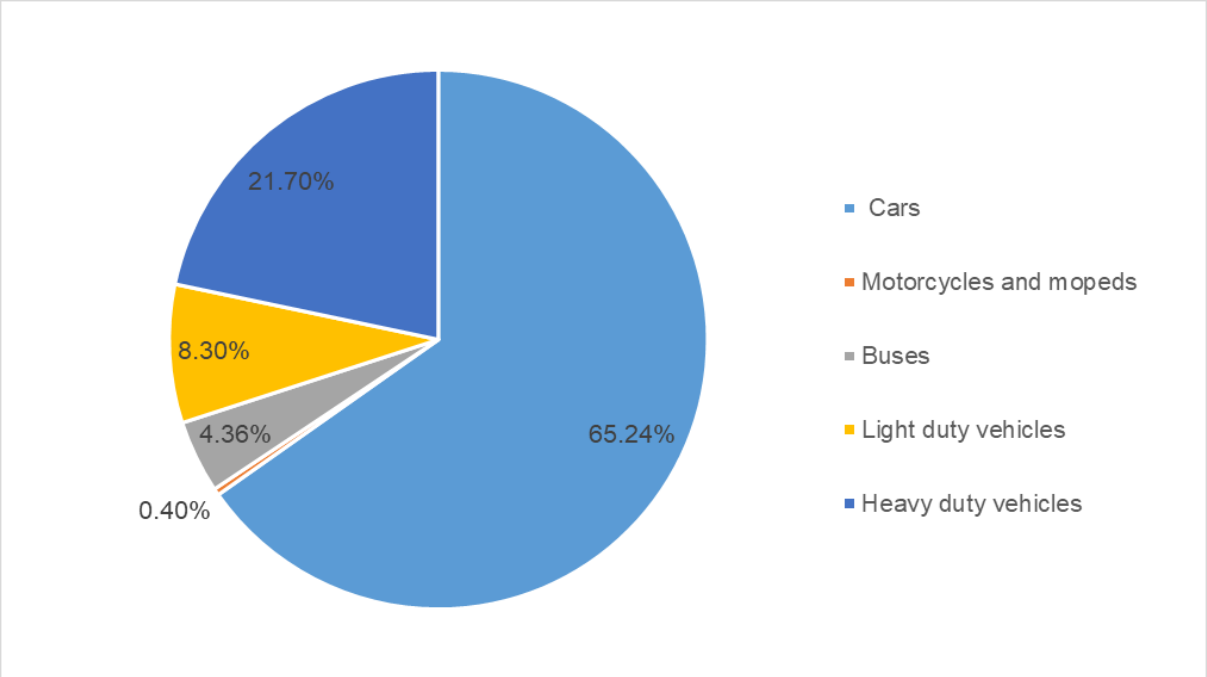
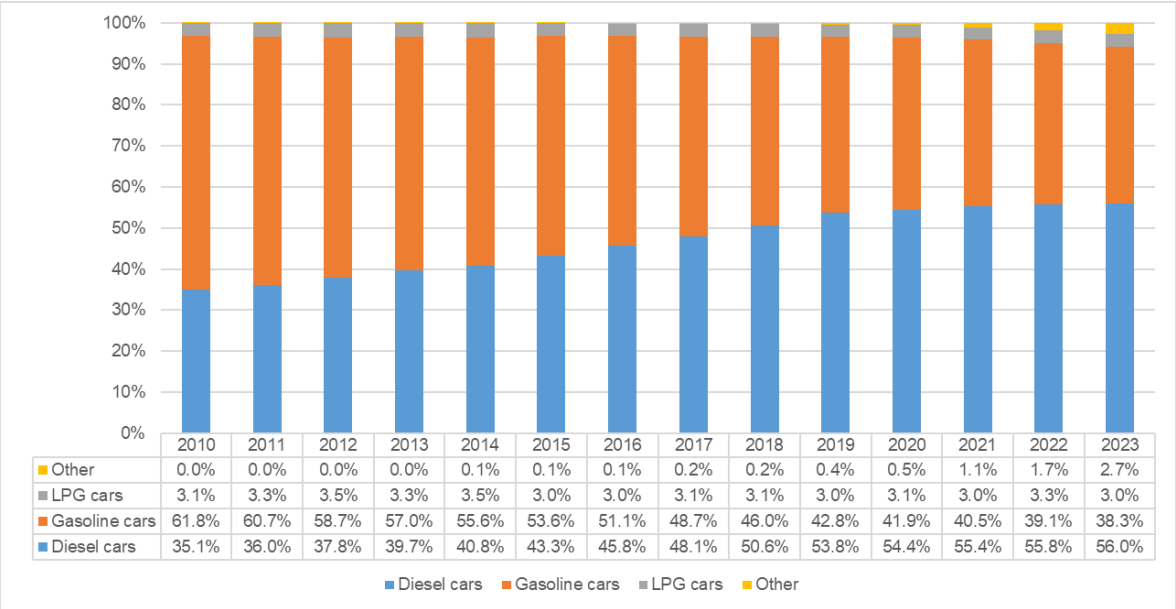


Figure 15 Structure of energy consumption

One indicator of energy efficiency in the transportation sector is the structural shift in passenger and freight transport modes. For instance, a higher share of freight transport by rail than road transport reflects a more energy-efficient freight system.

In Croatia, the structure of ton-kilometers and passenger-kilometers reveals that road transport remains the primary mode for freight and passenger movement. It is essential to implement measures that promote modal shift to address this. A modal shift entails accelerating the transition to greater use of rail and waterborne transport (for longer distances) and increasing reliance on public transport and active modes (cycling and walking) in urban areas.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Other	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.2%	0.4%	0.5%	1.1%	1.7%	2.7%
LPG cars	3.1%	3.3%	3.5%	3.3%	3.5%	3.0%	3.0%	3.1%	3.1%	3.0%	3.1%	3.0%	3.3%	3.0%
Gasoline cars	61.8%	60.7%	58.7%	57.0%	55.6%	53.6%	51.1%	48.7%	46.0%	42.8%	41.9%	40.5%	39.1%	38.3%
Diesel cars	35.1%	36.0%	37.8%	39.7%	40.8%	43.3%	45.8%	48.1%	50.6%	53.8%	54.4%	55.4%	55.8%	56.0%

Figure 16 Structure of passenger cars by fuel type

Given that rail transport continues to be the most energy-efficient solution for medium- and long-distance freight, removing operational and technical barriers between national rail networks, alongside fostering innovation and efficiency, should make rail freight more competitive compared to road transport. Modal transitions should also focus on expanding the use of inland waterways and short-distance maritime transport.

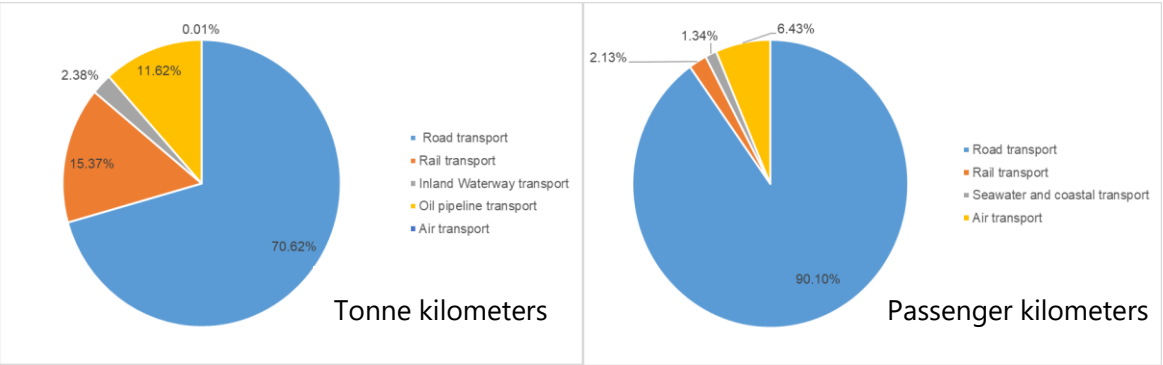


Figure 17 Modal structure of tonne and passenger kilometers in 2020

Energy efficiency policies

Croatia's energy efficiency policy in the transport sector prioritizes the adoption of alternative fuels and the use of more efficient vehicles. This is primarily achieved through fiscal measures, such as a special tax on motor vehicles, along with financial incentives to encourage the purchase of more efficient vehicles and the development of infrastructure to support alternative fuels, particularly in the area of e-mobility.

Some of the energy efficiency policies/measures:

- **Development of energy-efficient maritime transport and inland navigation** – The measure encourages the construction of an onshore electricity supply system for seagoing ships and inland waterway vessels. Supply of electricity from the mainland for ships and vessels *On-Shore Power Supply (OPS)* is a distributed energy system that reduces the need for ships and vessels to use built-in generators and helps reduce air pollution and noise in ports. In addition, the measure also envisages encouraging the construction of publicly available stations for the supply of hydrogen, ammonia and/or liquefied natural gas to seagoing ships and/or inland waterway vessels powered by hydrogen, ammonia or liquefied natural gas. Likewise, the measure involves co-financing the procurement of ships and alternative fuel vessels.
- **Development of energy-efficient rail transport** – This measure establishes the aim of constructing an appropriate number of stations for the supply of electricity or hydrogen from electric trains with a battery storage system and from hydrogen-powered trains on sections of the basic and comprehensive TEN-T network whose electrification is not possible for technical or cost reasons. In addition, in the period up to 2030, additional investments will be made in the renovation, modernisation, construction and maintenance of the railway infrastructure to enable better quality rail transport services, increase the number of service users, and thus increase the share of rail transport in total traffic.
- **Development of energy-efficient air transport** – The electricity supply should replace liquid fuel consumption in airports to reduce greenhouse gas and pollutant emissions. All aircraft in the commercial transport function should be able to use the external electricity supply while parked at exits or positions away from terminals at TEN-T airports. In this respect, it is necessary to build infrastructure for the electricity supply of stationary aircraft and infrastructure for the supply of preconditioned air (fixed or mobile systems that enable the external supply of conditioned air for cooling, ventilation or heating of stationary aircraft cabins).

Special focus: Energy poverty policies

The first problem when setting goals and measures to combat energy poverty is defining which households should be considered energy-poor. In most countries, including the Republic of Croatia, energy poverty is determined exclusively by the income census: households below a certain income level are considered energy poor.

Although socially vulnerable households are inevitably also energy-poor, it is essential to point out that low income is not the only cause of energy poverty. The practice of other countries shows that energy poverty, in addition to low income, is also caused by households' low energy efficiency, which results in a greater need for energy.

Accordingly, socially vulnerable households represent only a subset of energy-vulnerable households and most often represent households with the most acute problem of energy poverty. By focusing on socially disadvantaged households as the only category of energy-poor customers, other households suffering from energy poverty are ignored.

It is necessary to create a Program for combating energy poverty, adopt a multidimensional definition of energy poverty and determine measures and indicators for monitoring. As part of the Program, the following will be achieved:

- Establish the definition of energy poverty and analyse climate change impact,
- Evaluate the scope and socio-economic characteristics of energy-poor households,
- Establish the objectives of measures to combat energy poverty,
- Establish indicators for monitoring the success of the implementation of the energy poverty elimination program,
- Provide energy consulting for all energy-poor citizens of the Republic of Croatia,
- Establish a system of measuring and monitoring energy poverty indicators at the national level and
- Establish a system of increasing energy efficiency at the level of energy-poor households and households at risk of energy poverty.

Discussion and conclusion

The analysis of energy efficiency trends and policies in Croatia provides key insights into the progress made, as well as the challenges that remain. Over the past decades, Croatia has demonstrated a commitment to improving energy efficiency across various sectors, driven by national policies, EU directives, and financial incentives. However, while significant improvements have been made, further progress is needed, particularly in the industrial and transport sectors.

Key Findings

Economic and Energy Efficiency Trends: The Croatian economy grew by 3.1% in 2023, with total energy consumption rising at the same rate. While energy intensity continues to decline, economic growth remains linked to energy consumption.

Sectoral Performance:

- Industry: Some industries have improved efficiency, but energy-intensive sectors like chemicals and non-metallic minerals have seen rising energy intensity.
- Buildings: Renovation programs have had positive results, yet long-term commitments to deep renovation and nZEB standards are needed.
- Transport: Road transport dominates consumption. Progress in promoting alternative fuels and electrification has been slow, requiring further efforts.
- Renewable Energy Integration: The share of renewable energy in gross final consumption declined slightly in 2023 to 28.1%, highlighting the need for continued investment and policy support.
- Energy Poverty: Addressing energy poverty requires a broader approach beyond income levels, incorporating energy efficiency improvements and targeted social measures.

Challenges and Recommendations

Implementing energy efficiency policies is a challenge due to inconsistent enforcement and the need for continuity beyond EU funding cycles. Strengthening frameworks and monitoring is key to progress.

Energy efficiency varies across industries, with sectors like chemicals and non-metallic minerals seeing rising energy intensity. Supporting energy management systems and incentives can improve efficiency.

Transport remains energy-intensive, especially road transport. Expanding electric vehicle infrastructure, promoting fuel-efficient vehicles, and improving public transport are vital for sustainability.

The slight decline in renewable energy share in 2023 signals the need for more investment. Overcoming integration and investment challenges is crucial for Croatia's renewable sector.

Addressing energy poverty requires more than income measures. A comprehensive approach with efficiency upgrades and financial support can help vulnerable households lower energy costs.

Conclusion

Croatia has made commendable progress in improving energy efficiency, but further efforts are required to meet long-term targets and align with EU climate neutrality goals. A comprehensive approach integrating economic, technological, and social aspects will be essential for building a sustainable and resilient energy system. By strengthening policy implementation, accelerating transitions in industry and transport, and addressing energy poverty, Croatia can further solidify its role as a leader in energy efficiency within the region.

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