THE REPUBLIC OF CROATIA

MINISTRY OF ECONOMY AND SUSTAINABLE DEVELOPMENT

LOW-CARBON DEVELOPMENT STRATEGY OF THE REPUBLIC OF CROATIA UNTIL 2030 WITH A VIEW TO 2050

June, 2021

CONTENTS

LIST OF ABBREVIATIONS

Abbreviation	Meaning / Description
CBS	Central Bureau of Statistics
CCS	Carbon Capture and Storage
CNG	Compressed Natural Gas
COP	Conference of Parties
CSP	Concentrated Solar Power
DHS	District heating system
DHW	Domestic Hot Water
EC	European Commission
EPEEF	Environmental Protection and Energy Efficiency Fund
ESCO	Energy Service Company
ESI	European Structural and Investment Funds
ETS	Emissions Trading System
EU	European Union
FRL	Forest Reference Level
GDP	Gross Domestic Product
GHG	Greenhouse gas
GVA	Gross Value Added
HFCs	Hydrofluorocarbons
ICT	Information and Communications Technology
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Assessment
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LRTAP	Convention on Long-Range Transboundary Air Pollution
LRU	Local and regional self-government units
LULUCF	Land Use, Land Use Change and Forestry
MESD	Ministry of Economy and Sustainable Development
MFF	Multiannual Financial Framework
NECP	Integrated National Energy and Climate Plan for the Republic of Croatia
NMVOC	Non-methane volatile organic compounds
NPP	Nuclear Power Plant
NU1	Gradual transition scenario of the Low-Carbon Strategy
NU2	Strong transition scenario of the Low-Carbon Strategy
NUR	Reference scenario of the Low-Carbon Strategy
NUSPCRO	Low-Carbon Strategic Planning of the Republic of Croatia
nZEB	Nearly Zero Energy Building
OKFŠ	Forest general useful functions
PFCs	Perfluorocarbons
RES	Renewable Energy Sources
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WAM	Low-Carbon Strategy scenario With Additional Measures
WEM	Low-Carbon Strategy scenario With Existing Measures
CCS	Carbon Capture and Storage

1. OVERVIEW AND PROCESS OF STRATEGY DEVELOPMENT

1.1. SUMMARY

Legal basis for the drafting of the Low-Carbon Development Strategy of the Republic of Croatia

Today, global climate change is one of humanity's greatest challenges. It has been scientifically established that the leading causes of climate change are increased greenhouse gas emissions, mostly as a result of burning fossil fuels, intensive agriculture and deforestation.

The urgent need to work on climate change mitigation has been recognised on a global level, and the Republic of Croatia should contribute as much as possible by reducing greenhouse gas emissions. The Republic of Croatia participates in the achievement of the goal of the Paris Agreement on maintaining the temperature rise to a maximum of 2 °C with additional efforts to keep the temperature within 1.5 °C collectively within the framework of the European Union policy. Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council (OJ L 328, 21. 12. 2018), hereinafter: EU Regulation on Governance requires member states to draw up an integrated national energy and climate plan until 2030 and a long-term Low-Carbon Strategy until 2050. The Republic of Croatia is obliged to submit a Low-Carbon Strategy to the European Commission pursuant to Article 15 of the EU Regulation on Governance. All parties to the Paris Agreement, including the Republic of Croatia, must develop and submit to the UNFCCC Secretariat their long-term low-carbon strategies.

The Act on Climate Change and Ozone Layer Protection (Official Gazette, No. 127/2019) transposes the obligation from the EU Regulation on Governance by defining the obligation to develop a Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (hereinafter: Low-Carbon Strategy) and the Action Plan for the Implementation of the Low-Carbon Strategy for a period of five years. This is the first long-term strategy of the Republic of Croatia, which, in accordance with the prescribed structure from the EU Regulation on Governance, provides an analysis of the possibilities for the development of society towards a society with low greenhouse gas emissions. It presents three scenarios, which provide an overview of the efforts required to reduce greenhouse gas emissions in Croatia.

The purpose of this Low-Carbon Strategy is to initiate changes in Croatian society that will contribute to the reduction of greenhouse gas emissions and which will allow for the separation of economic growth from greenhouse gas emissions. The Republic of Croatia can and should contribute to the reduction of greenhouse gas emissions, in accordance with ratified international agreements, although its share on a global level in total greenhouse gas emissions is small. However, this is certainly an opportunity to make a turnaround in all sectors with the assistance of EU funds, in which all levels of government and the business world should participate. The transition of the Croatian society and economy into a low-carbon one should be achieved through investment in green business and technologies, in innovations and development, which will contribute to strengthening competitiveness in the common European market, which is increasingly seeking green products and services.

As part of the EU, Croatia shares the climate ambition expressed in the European Commission's European Green Deal (2019) for the EU to become climate neutral by 2050. Once all the implications of the EU's common target of reducing greenhouse gas emissions by -55% by 2030 and the 2050 climate neutrality target for sectoral policies are known, it will be possible to complete a zero-emissions scenario for Croatia.

The Low-Carbon Strategy is adopted by the Croatian Parliament, at the proposal of the Government of the Republic of Croatia. The Action Plan for the implementation of the Low-Carbon Strategy for a

period of five years is adopted by the Government of the Republic of Croatia, at the proposal of the state administration body competent for environmental protection.

Pursuant to the Act on the Strategic Planning System and the Management of the Development of the Republic of Croatia (Official Gazette, No. 123/2017), the Low-Carbon Strategy is a national, long-term and multi-sectoral strategy, which contributes to defining the umbrella National Development Strategy of the Republic of Croatia. The harmonisation of strategic and planning documents is also prescribed by the Act on Climate and Ozone Layer Protection, which stipulates that national development documents and development documents of certain areas and activities must be harmonised with the principles, basic goals, priorities and measures set out in the Low-Carbon Strategy.

The COVID-19 pandemic that broke out in 2020 has had a significant impact on the economy and society, and presents new uncertain circumstances for development. The Low-Carbon Strategy is all the more significant because additional financial resources for the recovery can accelerate the transition, create green jobs, achieve a resource-efficient economy based on Low-Carbon emissions and resilience to climate change. The impacts of the COVID-19 pandemic will be taken into account in the planning document, the Action Plan for the implementation of the Low-Carbon Strategy.

The Low-Carbon Strategy focuses on reducing greenhouse gas emissions and preventing an increase in their concentration in the atmosphere, and consequently limiting the global rise in temperature. However, climate change is already occurring because the greenhouse gases in the atmosphere are long-lived, but also because international climate agreements are not being implemented at an appropriate pace.

Climate change is the biggest challenge facing the world, and is causing great damage to the economy, society and ecosystems. It is therefore important to simultaneously work on the strengthening of resilience to climate change, and to implement adaptation measures in order to minimise damage and take advantage of opportunities. In selecting appropriate low-carbon development measures, the risks of climate change should be taken into account, as well as the fact that the selected measures contribute to adaptation to climate change, and vice versa. The 2019 report of the Intergovernmental Panel on Climate Change states that the global trend of temperature rise is already at + 1.1 °C, and if the concentration of greenhouse gases continues to increase at the current rate, global warming is likely to reach + 1.5 °C between 2030 and 2052.

There is growing evidence that Croatia is impacted by climate change and that Croatia is already suffering great damage from extreme weather events, which are exacerbated by climate change. According to the Climate Change Adaptation Strategy for the period until 2040 with a view to 2070 (Official Gazette, No. 46/2020), it is to be expected that the air temperature in Croatia will increase by between 1.3 and 1.5 °C by 2040, i.e. by between 2.2 and 2.5 °C by 2070, which affects a number of climatic parameters.

Strategy Development Process

The Low-Carbon Strategy was developed in an inclusive and transparent manner involving a number of stakeholders from all major groups, in four steps.

The **first step** began in 2012 through the Low Emission Development Strategies (LEDS) Project of the Ministry of Environmental and Nature Protection, in partnership with the United Nations Development Programme (UNDP). With this project, in a series of sectoral workshops, the Framework for the Drafting of the Low-Carbon Development Strategy of the Republic of Croatia (LEDS) was prepared.

In the **second step**, from 2014 to 2015, with the participation of many institutions, expert basic documents were prepared, which resulted in a Green Paper (detailed technical analyses of goals, measures, scenarios and impacts) and a White Paper (Draft Low-Carbon Strategy). During the preparation of the expert basic documents, a series of sectoral workshops and public presentations were

held, in order to involve the expert and interested public in the preparation of the expert basic documents. The process of strategic environmental impact assessment with the main assessment of acceptability for the ecological network was initiated.

In the **third step**, from 2016 to 2017, new calculations and amendments to the low-carbon scenarios were carried out. The reason for this were changes in the historical data set, changes in fuel prices and technologies, and new assumptions in development policies. In consultation with the relevant ministries, a second revision of the White Paper was carried out, i.e. the Draft Low-Carbon Development Strategy. The process of the strategic environmental assessment with the main assessment of acceptability for the ecological network was continued, and a public consultation on the Draft Low-Carbon Development Strategy and the Strategic Environmental Impact Study of the Low-Carbon Development Strategy was conducted.

In the **fourth step**, from 2019 to 2020, amendments to the White Paper were carried out. Namely, the Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 was also developed at the time (hereinafter: Energy Strategy), as well as the Integrated National Energy and Climate Plan for the period from 2021 to 2030 (hereinafter: NECP), and in coordination and through an iterative approach, consistent targets for reducing greenhouse gas emissions in the energy sectors have been set. At the same time, the reference and low-carbon scenarios of the non-energy sector (industrial processes and product use, agriculture, waste, land use, land-use change and forestry - LULUCF) were updated.

Methodological approach

In the drafting of the Low-Carbon Development Strategy, a number of scenarios were analysed, numerous models for simulations and optimisations were applied, and an integrated model for national greenhouse gas projections, NUSPCRO (Low-Carbon Strategic Planning of the Republic of Croatia), was developed. Greenhouse gas emissions and projections are reported in accordance with the methodology of the 2006 Intergovernmental Panel on Climate Change (IPCC 2006) and the corresponding greenhouse potential factors for calculating CO_2 emission equivalents.

Greenhouse gas emissions

In 2018, total greenhouse gas emissions in the Republic of Croatia, excluding sinks, amounted to 23,792.80 kt CO_2e, which represents a reduction in emissions by 25.36%, compared to greenhouse gas emissions in 1990. The trend of greenhouse gas emissions by sector is shown in Figure 1-1.

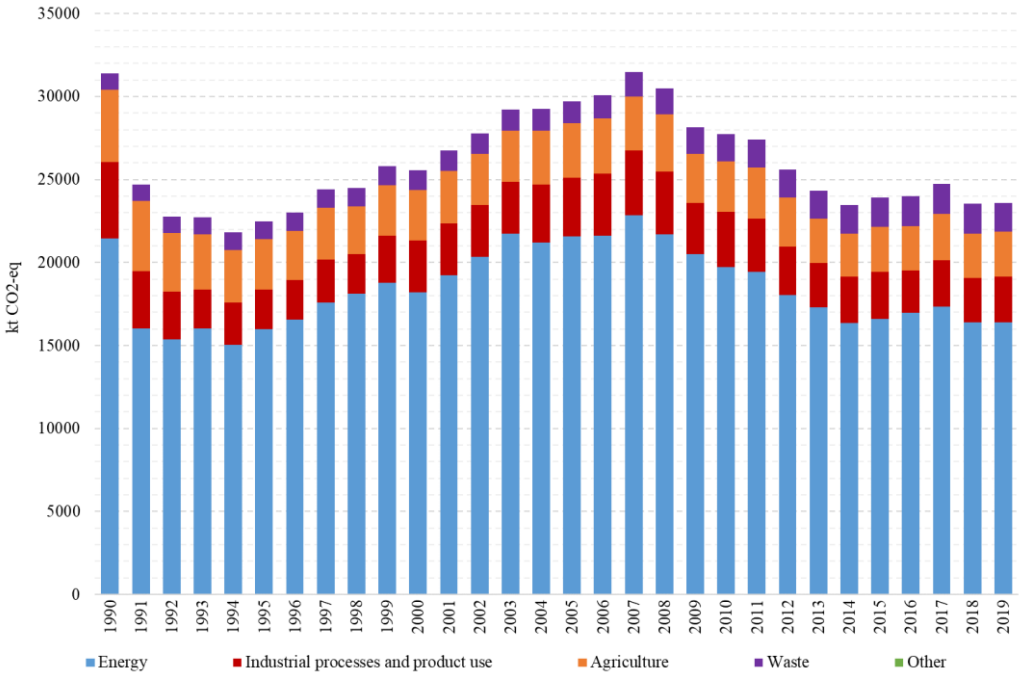

Figure 1-1: Trend of greenhouse gas emissions by sector

In the total greenhouse gas emissions, carbon dioxide (CO_2) accounts for 74.5%, methane (CH_4) 16.3%, dinitrogen oxide (N_2O) 7.1%, and fluorinated hydrocarbons 2.1%. The EU Emissions Trading System (EU ETS) includes all energy sources with an input nominal thermal power greater than 20 MW (thermal power plants, refineries), the mineral products industry (cement, glass, bricks), the chemical industry and the iron and steel industry. ETS emissions account for 31.3% of total greenhouse gas emissions in 2018.

The emission intensity per gross domestic product (GDP) decreased by 34% in the period from 2004 to 2018, i.e. by about 2.5% per year.

Vision of the Low-Carbon Development Strategy

The Low-Carbon Development Strategy leads to a vision of a society in which we will live healthier and more comfortably, with low-carbon growth and efficient resource management. The existing national building stock will be renovated, and new buildings will be built according to the principles of nearly zero energy buildings and the circular economy. Energy supply will be more secure, from renewable sources and with low emissions, and energy consumers will also be energy producers. The combination of on-site electricity generation and public grid supply will provide a high level of security of electricity supply. The transport system will be intermodal and integrated, mainly with electric vehicles and with the use of low-carbon and climate-neutral fuel. Industry and agriculture will be efficient and connected to all sectors of the economy, while reducing the generation of waste materials in an integrated and circular economy.

Objectives and scenarios of the Low-Carbon Development Strategy

The Low-Carbon Development Strategy is paving the way for the transition to a sustainable competitive economy, in which economic growth is achieved with low greenhouse gas emissions. The goals of reducing greenhouse gas emissions by 2030 and 2050 will be implemented in the Republic of Croatia within the political framework adopted by the European Union. The new growth strategy of the European Union (EU), formulated through the European Green Deal (2019), aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050.

The general objectives of the Low-Carbon Development Strategy are the following:

- achieving sustainable development based on knowledge, a competitive low-carbon economy and efficient use of resources
- increasing the security of energy supply, sustainability of energy supply, increasing energy availability and reducing energy dependence
- solidarity by fulfilling the obligations of the Republic of Croatia under international agreements, within the framework of EU policy, as part of our historical responsibility and contribution to global goals
- reduction of air pollution and the impact on the health and quality of life of citizens.

About a hundred measures have been selected that can be applied to reduce emissions (technical and non-technical), in different sectors: electricity and heat production, fuel production and processing, transport, general consumption (households and services), industry, agriculture, land use, land-use change and forestry, waste, product use and fugitive emissions (Annex V). **These measures have been incorporated into the three main scenarios: Reference Scenario (NUR), Gradual Transition Scenario (NU1) and Strong Transition Scenario (NU2).**

The reference scenario (NUR) is a continuation of existing practice, in line with current legislation and accepted targets by 2030. This scenario assumes technological progress and the growth of the share of renewable energy sources and energy efficiency based on the market situation and the target energy standards set today. Compared to the low-carbon scenarios for achieving the objectives, this is a scenario with a slight increase in the share of renewable energy sources and energy efficiency. Emissions in this scenario decrease by 28.9% in 2030 and 46.3% in 2050, compared to the 1990 emissions level. The share of renewable energy sources in this scenario is 35.7% in 2030 and 45.5% in 2050. However, this scenario does not lead to a low-carbon economy.

The gradual transition scenario (NU1) is sized to meet the emission reduction objectives under the EU's internal commitment scheme, and the related objectives of the Paris Agreement to keep the temperature rise within 2 °C and preferably within 1.5 °C. In this scenario, emission reductions are achieved through the application of a series of cost-effective measures, strong incentives for energy efficiency and the use of renewable energy sources that could be largely market-competitive in electricity generation after 2030. The scenario assumes a strong increase in the prices of emission allowances, which represent the right to emit one ton of CO_2 equivalent (hereinafter: emission allowance), up to 92.1 EUR/t CO_2 in 2050, which is the main driver of the transition. The share of renewable energy sources in 2030 under this scenario is 36.4%, and in 2050 it could be 53.2%. The NU1 scenario reduces greenhouse gas emissions by 33.5% in 2030 and 56.8% in 2050, compared to 1990.

The strong transition scenario (NU2) is sized with the aim of achieving an 80% reduction in emissions in 2050, compared to 1990. In this scenario, as well as in the NU1, a strong increase in emission allowance prices up to 92.1 EUR/t CO_2 in 2050, and very strong energy efficiency measures are assumed. The share of renewable energy sources in 2030 under this scenario is 36.4%, and in 2050 it could be 65.6%. In this scenario, in 2050, the dominant source of emissions remains transport, followed by agriculture and industry. By applying the measures known today, including those that are socio-economically acceptable for agriculture, an emission reduction of 73.1% could be achieved compared to 1990. The remaining amount up to 80% is accounted for by new technologies that are not yet in use today, i.e. underdeveloped technologies.

The **net zero emissions scenario (climate neutrality)** is included in this document in the form of information (Chapter 15). On 17 September 2020, the European Commission published the Communication "Stepping up Europe's 2030 climate ambition - Investing in a climate-neutral future for the benefit of our people", as an important element for implementing the European Green Deal and achieving climate neutrality by 2050, in which it proposed an increase in EU's target for reducing greenhouse gas emissions by 2030, from the existing -40% to -50 to -55%. At the European Council

meeting on 10 and 11 December 2020, the Prime Ministers adopted the target of reducing emissions for the EU by at least -55% by 2030. The next step is to change the entire EU legislation that prescribes climate policy until 2030, and which partly prescribes the targets of the member states in this period. Following all the above-mentioned expected changes in EU regulations, strategic and other documents in the Republic of Croatia will be amended regarding the finalisation of the net zero emissions scenario in the Republic of Croatia, in order to foster the transition to low-carbon development with the aim of achieving climate neutrality by 2050, and strengthening resilience to climate change. The net zero emissions scenario will analyse the possibilities of achieving a zero net rate of greenhouse gas emissions in 2050 in a cost-effective way and through a socially just transition.

The NU1 and NU2 scenarios are very similar until 2030, so if the **Republic of Croatia starts with the gradual transition scenario (NU1), it has time to switch to the more ambitious strong transition scenario (NU2).**

The goal is for the GHG emission pathway to be in a range between the NU1 and NU2 scenarios, with a tendency towards the more ambitious NU2 scenario (Figure 1-2).

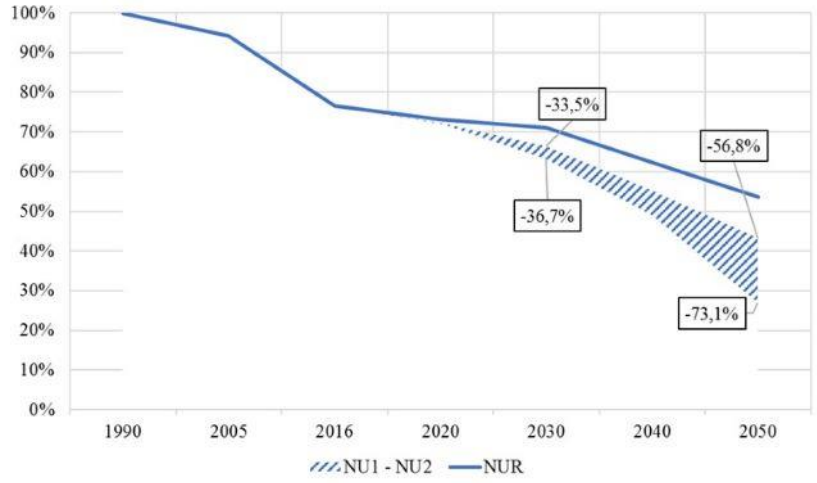

Figure 1-2: Reduction of greenhouse gas emissions according to the NUR, NU1 and NU2 scenarios

In 2030, compared to 1990 levels, in the NU1 scenario, a total reduction of 33.5% is achieved, while in the NU2 scenario, a reduction of 36.7% is achieved. The largest contribution to this decrease was made by the industrial sector (43%), followed by the fuel production and processing sector (18%), the agricultural sector (15%), the electricity and heat production sector (14%) and the general consumption sector (10%). In the transport and waste sectors, emissions in 2030 are still higher than in 1990, as emissions from these sectors recorded an increase until 2018.

In 2050, in the NU1 scenario, a total decrease of 56.8% is achieved, while in the NU2 scenario, a decrease of 73.1% is achieved, compared to 1990. The largest contribution to this decrease was made by the industrial sector (36%), followed by the electricity and heat production sector (15%), the fuel production and processing sector (14%), the general consumption sector (13%), the agricultural sector (11%), the transport (9%) and the waste sector (1.3%).

Financing

In the long term, investments in low-carbon projects need to be economically viable. Public sources of financing will not be sufficient, and instruments need to be found to mobilise private funds to invest in businesses that contribute to the Low-Carbon Development Strategy and economic growth.

It is estimated that the transition to low-carbon development will require HRK 38.65 to 65.92 billion in the period from 2021 to 2030, i.e. from 0.92 to 1.6% of the GDP. In the period from 2031

to 2050, the cost will amount to between HRK 107.09 and 167.95 billion (from 0.96 to 1.51% of the GDP). The above indicated investment amounts represent the difference in the investments between the transition scenarios (NU1 and NU2) and the reference scenario (NUR).

The framework for the financing of measures already exists to a large extent, in terms of possible sources of funding. For projects that will have a positive impact on the climate, the Republic of Croatia will have at its disposal funds in the total amount of about HRK 62.4 billion, of which HRK 36 billion will come from the Multiannual Financial Framework (MFF) until 2027, HRK 16.65 billion from the Recovery and Resilience Fund and HRK 2.7 billion from the Modernisation Fund, and about HRK 5.7 billion in revenues from auctions of emission allowances within the greenhouse gas emissions trading system. Also, the Republic of Croatia will have at its disposal about HRK 1.3 billion from the Just Transition Fund. These funds should also be directed towards measures to reduce risks and adapt to climate change, in order to increase the resilience of the Republic of Croatia, reduce vulnerability and reduce the cost of damage caused by climate change. In addition to this, a secure source of funding will come from the Innovation Fund, the Connecting Europe Fund, the European Fund for Strategic Investments, etc. Other sources of funding such as Horizon 2020 and Horizon Europe, as well as the LIFE programme, are competitive in nature.

The Republic of Croatia will have significant financial resources at its disposal, but the investment needs to exceed the available funds significantly. This is why inter-sectoral coordination and the use of innovative financial instruments (ESCO model, etc.) will be necessary, in order to achieve the greatest possible multiplier effect in terms of reducing emissions with the limited financial resources at our disposal, given that all sectors will have to contribute to reducing emissions in order for the Republic of Croatia to meet its share of the reduction in the EU target of -55% by 2030.

A new funding perspective is opened up by the European Green Deal and additional funding for climate action, including new funding instruments at national level.

Funds earmarked for EU solidarity assistance for economic recovery and job preservation, due to the impact of the COVID-19 crisis, will give priority to promoting a green economy and digitalisation. From the point of view of greenhouse gas emissions, the necessary priority interventions in transport, energy-intensive industry, buildings and renewable energy sources have been identified.

Impact of the scenario on the environment and nature

Although the implementation of the Low-Carbon Development Strategy has a positive effect on reducing greenhouse gas emissions, some aspects of Low-Carbon development pose a potential threat to certain components of the environment and nature. For the Low-Carbon Development Strategy, a strategic environmental assessment procedure was carried out, which included the major assessment of the acceptability for the ecological network. Environmental protection measures and measures aimed at mitigating the effects on the conservation objectives and the integrity of the ecological network area, are an integral part of the Low-Carbon Development Strategy.

Socio-economic impacts

The overall expected benefits for society (taking into account external costs) are positive, and result in a lower overall social cost. The main challenge of the implementation and the pace of the changes is the need for high investments that can pose a significant challenge for certain segments of the economy and/or customers. A limiting factor of an accelerated transition may be the ability of the economy, society and individuals to participate in the processes in a timely manner, due to large initial investments, regardless of the fact that the transition processes bring long-term benefits to society and the environment.

Low-carbon development can bring net benefits to society, but additional EU funds are needed to implement the measures.

Education and active involvement of citizens in low-carbon development

The education system should become a leader in promoting the principles of low-carbon development; young people entering the education system today will be the promoters of change in the future, and without their knowledge and conviction, the goals of the Low-Carbon Development Strategy will not be implemented. Therefore, this is a priority activity of the Low-Carbon Development Strategy, more important in the long run than any type of technical measure.

In the period from 2021 to 2030, education on sustainable development and climate change in Croatia will be developed, supplemented and modernised, and generations of citizens of the Republic of Croatia who will be fully and systematically "climate aware" will be created.

Also, in the period until 2030, a more rapid change in the understanding and patterns of behaviour is envisaged in terms of the Republic of Croatia becoming a low-carbon society. On the one hand, awareness of climate issues will grow systematically, and on the other hand, new skills will need to be taught to meet the challenges of the transition to low-carbon development. Thirdly, low-carbon practical solutions will need to be built into social life, production, consumption and development management in the direction of increasing sustainability.

Research, development and innovation

Previous investments in research, development and innovation on climate change have been completely negligible, and insufficiently recognised in existing strategic documents. Research and development are among the biggest potential factors contributing to GDP growth, immediately after increases in employment, which is why Croatia needs to increase its R&D expenditure to move closer to the EU average. Access to funds should also be provided to the private sector, for applied scientific and development research, and pilot and demonstration projects. The ministry competent for climate policy, inter-coordination bodies and representatives outside the public sector should be strongly involved in the planning of funding programmes and in the monitoring of implementation.

The elements of low-carbon development need to be integrated into programmes to foster innovation, research and development of high technologies in the private and public sectors.

Low-carbon development at local level

The implementation of the Low-Carbon Development Strategy should establish better coherence and synergies of policies at state and local levels. Activities are increasingly shifting to independent activities of local governments and cities. More ambitious initiatives, such as carbon neutral islands, cities and the like, should be supported. It is especially important to connect the activities carried out within the international initiative "Covenant of Mayors", the concept of "smart cities" and "smart islands" and innovative platforms. At local level, the mitigation and adaptation measures to climate change are linked, and the synergy of resource use is the strongest.

The Low-Carbon Development Strategy indicates the need to implement a number of measures in the planning and construction of integrated systems in cities. These include public and other transport, buildings, utilities, autonomous systems, education systems, information and communication technologies (ICT), urbanism, innovative solutions in various fields and raising public awareness.

Low-carbon economy and business patterns

Regarding business patterns, the most significant is the transformation of business according to the principles of the circular economy. It is necessary to implement a policy of sustainable consumption and production, to encourage sustainable patterns of behaviour and business in all economic sectors. The Life Cycle Assessment (LCA) concept, which monitors the environmental footprint of products and services and is based on scientific indicators, should be implemented. The aim is to reduce the

consumption of natural resources, reduce the generation of hazardous and toxic substances, reduce emissions to air, water and soil, and reduce or prevent the generation of waste at the place of origin.

The application of the principles of low-carbon development in business organisations is mostly voluntary, which means that the leaders of organisations apply these principles expecting to achieve some benefit in the long term. This is why success depends on two elements: primarily on raising awareness and educating those responsible for managing organisations and making key business decisions (senior management), and on creating a supportive business environment in which organisations will recognise the benefits of applying the principles of low-carbon development, with the understanding that this benefit is not necessarily material or can at least materialise in the long run.

Regarding specific measures, they need to me aimed at encouraging the establishment of quality systems, environmental management systems, carbon footprint, environmental licensing, green public procurement, etc. This includes the construction of adequate IT infrastructure, databases and budget models.

International cooperation

The United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement indicate the obligation to cooperate, and that developed country parties will assist developing country parties in supporting capacity building measures to mitigate and adapt to climate change. With its membership of the EU, the Republic of Croatia enters the category of developed countries in the world, and through the national policy of international development aid, it should develop assistance programmes for selected developing country parties on the topic of climate change. In addition, the Republic of Croatia participates in the creation of international development assistance of the EU, which, as a Party of the UNFCCC and the Paris Agreement, is the largest single donor in the world for climate policy.

Implementation of the Low-Carbon Development Strategy

The process of transition to a low-carbon economy is continuous and long-lasting and affects the whole of society and the economy. This is why the successful implementation of the Low-Carbon Development Strategy requires horizontal cross-sectoral cooperation between central state administration bodies and public authorities, as well as vertical cooperation from state level to action at local level.

In order to integrate low-carbon development into key aspects of society and the economy, it is to be expected that the existing legal framework and development documents of individual areas will be adjusted. Cross-sectoral cooperation is coordinated by the Inter-Sectoral Coordination Commission for the National Greenhouse Gas Emissions Monitoring System and the Inter-Sectoral Coordination Commission for Policy and Measures for Climate Change Mitigation and Adaptation.

The state administration body competent for climate change policy reports to the European Commission on the implementation of the Low-Carbon Development Strategy through the Report on the Implementation of the Low-Carbon Development Strategy within the deadlines set by regulations, i.e. in accordance with the schedule agreed at international level in the context of the UNFCCC.

Strategic environmental assessment of the Low-Carbon Development Strategy

In accordance with the regulations governing environmental protection, a strategic environmental impact assessment procedure was carried out for the Low-Carbon Development Strategy. The strategic study examines the possible impact of the Low-Carbon Development Strategy on the environment and the ecological network, and identifies environmental protection measures and measures mitigating the impact on the conservation objectives and the integrity of the ecological network area.

1.2. LEGAL CONTEXT AND POLICY CONTEXT

Today, global climate change is one of humanity's greatest challenges. It has been scientifically established that the leading causes of climate change are increased greenhouse gas emissions, mostly as a result of burning fossil fuels, intensive agriculture and deforestation. Joint action by states to prevent global change is implemented through the UNFCCC. The Kyoto Protocol to the UNFCCC and the Doha Amendment to the Kyoto Protocol have not prevented a global increase in emissions. With the Paris Agreement (2015), states have committed themselves to working together to reduce greenhouse gas emissions with the aim of limiting the rise in average global temperature to a maximum of 2 °C by the end of the century, and making additional efforts to limit temperature rise to 1.5 °C. Greenhouse gas emission reduction targets are determined by the plans of each visit, so that each party to the Paris Agreement (or group of states) determines the planned nationally determined contribution by 2025 or 2030.

The Republic of Croatia has been a party to the Paris Agreement since 2017, thus committing itself to implementing measures to reduce greenhouse gas emissions within the framework of EU obligations.

The starting point of the EU's policy towards a low-carbon economy is the EU Climate and Energy Policy Framework until 2030, which sets the following goals:

- reducing greenhouse gas emissions by at least 40%, compared to 1990 levels
- at least 32% of the energy consumed should be from renewable sources
- improving energy efficiency by at least 32.5%.

At the end of 2018, the document *A Clean Planet for all – A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy* was published. The purpose of this long-term strategy, adopted and submitted to the UNFCCC Secretariat in March 2020, is to reaffirm Europe's leading role in shaping global climate policy and present a vision that can help to achieve a net zero greenhouse gas emission rate by 2050, in a cost-effective way and through a socially just transition, and it is expected that in the coming years, through intensive analyses and discussions of Member States, possible zero net greenhouse gas scenarios will be analysed.

At the end of 2019, the European Commission announced its new strategic policy framework for even more ambitious action - the European Green Deal. This is the first time that climate and environmental goals have been placed at the heart of political action, as the EU seeks to transform itself into a just and prosperous society with a modern, resource efficient and competitive economy, in which there will be no net greenhouse gas emissions in 2050, and in which economic growth is decoupled from resource use. The European Green Deal will accelerate and support the transition needed in all sectors, and contribute to the implementation of the United Nations 2030 Agenda and its Sustainable Development Goals.

In mid-2020, the European Commission, together with 14 EU Member States, including the Republic of Croatia, signed a Memorandum of Understanding Implementing the Valletta Political Declaration On Clean Energy for European Union Islands (Memorandum of Split), which aims to improve energy transition on the islands, while respecting the specifics of each island, and to expand and strengthen cooperation between Member States. The Republic of Croatia initiated the signing of the Memorandum during its presidency of the Council of the European Union. The memorandum ensures detailed support to the islands in preparing their strategies for the process of transition to clean energy and cooperation of energy communities on the islands. It recognises the importance of implementing projects aimed at increasing the use of renewable energy sources through the use of innovative technologies, the development of clean and sustainable transport, and the integration of the electricity system with other sectors. The memorandum takes into account the goals of the Paris Agreement and the European Green Deal, the goals of achieving a climate-neutral EU by 2050, the Clean Energy for all Europeans legislative package, as well as the national energy and climate plans.

The EU Regulation on Governance prescribes the development of the NECP for the period until 2030 and the long-term Low-Carbon Strategy until 2030 with a view to 2050, and the obligation to harmonise these. The provisions of the EU Regulation on Governance have been transposed into the Act on Climate Change and Ozone Layer Protection.

The Act on Climate Change and Ozone Layer Protection stipulates the obligation to develop a Low-Carbon Strategy and an Action Plan for the implementation of the Low-Carbon Strategy for a period of five years. According to the Act on Climate Change and Ozone Layer Protection, the reduction of greenhouse gas emissions in the territory of the Republic of Croatia is ensured by implementing the Low-Carbon Strategy, the Action Plan for the Implementation of the Low-Carbon Strategy, the NECP, development documents of individual sectors, gradual limitation of emission allowances within the EU Emissions Trading Scheme, by allocating an established annual emission quota to the Republic of Croatia for sectors outside the EU Emissions Trading System, which may not be exceeded, measures in sectors outside the ETS, measures in the land use and forestry sector and other measures contributing to climate change mitigation. The Act on Climate Change and Ozone Layer Protection stipulates that national development documents and development documents of individual areas and activities must be harmonised with the principles, basic goals, priorities and measures set out in the Low-Carbon Strategy.

The Low-Carbon Strategy determines the path of the Republic of Croatia towards a competitive economy with low greenhouse gas emissions. The goals of reducing greenhouse gas emissions by 2030 and 2050 will be implemented in the Republic of Croatia within the political framework adopted by the European Union. The Low-Carbon Strategy applies to all sectors of the economy and human activities, and is particularly related to energy, industry, transport, agriculture, forestry and waste management.

The process of transition to a low-carbon economy is continuous and long-lasting, and affects the whole of society and the economy. The transition process needs to be thought-through and adapted to the possibilities and available resources. It is an opportunity to improve the growth of industrial production, the investment cycle, development of new activities, the economy, and to create new jobs with sustainable perspectives by improving the existing infrastructure and technological solutions, innovations, transfer of advanced technologies, and significant structural changes in all sectors.

The Low-Carbon Strategy sets the following general objectives:

- **Achieving sustainable development based on knowledge and a competitive low-carbon economy and efficient use of resources:**
    - increasing employment in growing sectors of the economy and the 'green' economy,
    - stimulating regional and rural development,
    - stimulating innovation and technological development,
    - stimulating education, lifelong learning and specialisation in the low-carbon economy,
    - contribution to social inclusion.
- **Increasing the security of energy supply, sustainability of energy supply, increasing energy availability and reducing energy dependence.**
- **Solidarity by fulfilling the obligations of the Republic of Croatia under international agreements, within the framework of EU policy, as part of our historical responsibility and contribution to global goals.**
- **Reduction of air pollution and the impact on the health and quality of life of citizens.**

With regard to international obligations, the Republic of Croatia supports the principle of common but different responsibilities. Economic and other national characteristics should be taken into account when determining the transition period for the transition to a low-carbon economy. Through the Low-Carbon Strategy, the Republic of Croatia should take the path that is most favourable for its citizens.

Therefore, the Low-Carbon Strategy:

- creates synergies with the concept of developing new green businesses and the economy, the concept of a circular economy in which resources are used to the maximum, and waste generation is kept to a minimum;
- provides a vision of individual sectors until 2050 in the context of low-carbon development, but this is applicable to society and the economy as a whole;
- sets the following general principles: sustainable development, polluter pays[1], application of the horizontal principle, flexibility, inclusiveness, innovation, solidarity, synergy, integrity (holistic approach) and long-term planning;
- recognises that sustainable development is a balance between economic growth, environmental protection and social development. The costs of measures to reduce greenhouse gas emissions must not jeopardise economic development. The implementation of low-carbon development measures should be financed by pollutants, with burden sharing being fair, and financing models simple and transparent.

The application of the horizontal principle implies spreading across all sectors and capillary involvement in relevant policies at national level. For example, energy saving measures should be considered as a new energy source and valued as much as building new energy capacities. Likewise, measures to increase greenhouse gas sinks in forest management activities and agriculture should be encouraged, i.e. they should be considered as emission reduction measures. Flexibility means that low-carbon development needs to be open enough to take into account possible external geopolitical circumstances and other disruptions, leaving individual sectors with ample opportunity to decide on their own targets. Inclusion implies the contribution of all sectors to the reduction of greenhouse gas emissions, even those that contribute to emissions indirectly.

Innovation and smart solutions are prerequisites for international and global competitiveness. The Republic of Croatia should show solidarity internationally, and solidarity should also be encouraged between sectors. Greater effects are achieved if the conditions for synergistic action can be created, and activities and measures of such action should be encouraged. The principle of integrity is particularly important when planning low-carbon development.

The Low-Carbon Strategy supports twelve of the thirteen objectives of the National Development Strategy of the Republic of Croatia until 2030: A competitive and innovative economy, educated and employed people, global recognition and strengthening of the international position and role of the Republic of Croatia, healthy, active and quality life, demographic revitalisation and better position of the family, security for stable development, ecological and energy transition for climate neutrality, self-sufficiency in food and development of the bioeconomy, sustainable mobility, digital transition of society and the economy, the development of assisted areas and areas with development specificities, and the strengthening of regional competitiveness.

1.3. CHRONOLOGY OF THE DEVELOPMENT OF THE LOW-CARBON STRATEGY AND PUBLIC CONSULTATIONS

The Low-Carbon Strategy was developed in four steps. Each step involved consultations with the expert and interested public.

[1] Environmental Protection Act (Official Gazette, No. 80/13, 153/13, 78/15, 12/18, 118/18)

First step (2012-2013)

The first step began in 2012 through the LEDS Project, in partnership with the UNDP, which led to the development of the Framework for the Drafting of the Low-Carbon Development Strategy of the Republic of Croatia. The focus of the project was on broad consultations by sector, the organisation of a series of sectoral workshops: energy plants (production, consumption, import and export of energy), buildings, transport, industry, agriculture and forestry, waste and tourism. At the workshops, participants actively participated in the analysis of strengths, weaknesses, opportunities and threats (SWOT analysis), and in establishing the vision of low-carbon development. Priority measures and guidelines for the development of the Low-Carbon Strategy have also been identified. The framework for the development of the Low-Carbon Strategy was then adopted within the Plan for the Protection of Air, the Ozone Layer and Climate Change Mitigation in the Republic of Croatia for the period from 2013 to 2017.

Second step (2014-2015)

In the second step, expert basic documents for the Low-Carbon Strategy were prepared. The drafting process ran along two lines, with the analytical work of preparing expert basic documents, and parallel consultations with stakeholders and the interested public. Stakeholder consultations also included sectoral workshops for energy plants (production, consumption, import and export of energy) and industry, transport, buildings, agriculture and forestry, and waste. At the workshops, participants presented the internal factors (strengths and weaknesses) and external factors (opportunities and threats) that characterise the current situation in the sectors. Low-carbon development was considered within the general economic and social development of the Republic of Croatia, and structural reforms in certain sectors that directly or indirectly affect the more rational and efficient management of natural resources and reduction of environmental impact. In addition to the above workshops, the results of the expert basic documents of the Low-Carbon Strategy were presented at conferences, forums and professional gatherings.

A Green Paper was prepared, which provided detailed technical descriptions and data, described models, methods, measures, scenarios, effects of low-carbon scenarios on the economy, society and the environment, sensitivity analysis, guidelines, funding, etc. Based on the Green Paper, the first version of the White Paper was drafted, presenting a summary of the results, focusing on selected measures, scenarios and policies, with guidelines for implementation, including the necessary financial mechanisms. The White Paper presents the Draft Low-Carbon Strategy. The process of strategic environmental impact assessment was initiated.

Third step (2016-2017)

In the third step, new calculations and amendments to the low-carbon scenarios were carried out, as well as the first revision of the White Paper. There are three main reasons why it was reasonable to implement a re-calculation.

The first reason is that in 2016, changes to the historical data set on energy occurred, so in this regard, it was necessary to repeat the calculation of greenhouse gas emissions for the period from 1990. The second reason is a change in key factors: the price of fossil fuels (especially gas), the projected prices of emission allowances, a significant drop in the prices of renewable energy technologies (especially solar power plants). The third reason is the change of the Government of the Republic of Croatia at the end of 2016, which set new development guidelines for the period from 2017 to 2020, so in this regard, there was a need to review certain goals, policies and measures.

During the drafting of the White Paper revision, consultative meetings were held with the relevant ministries. The process of strategic environmental impact assessment continued, and in 2017, a public consultation was held on the proposal of the Low-Carbon Development Strategy of the Republic of

Croatia until 2030 with a view to 2050, and the Strategic Environmental Impact Study of the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050.

At the end of 2017, the drafting of the Energy Strategy and the NECP for the period from 2021 to 2030 began. The obligation to harmonise the NECP and the Low-Carbon Strategy is based on the EU Regulation on Governance, so the adoption of the Low-Carbon Strategy was postponed in order to align the objectives of all these documents.

Fourth step (2019-2020)

The energy strategy determines emission reductions in the energy sectors: energy production and transformation plants, industry and construction, road and off-road transport, non-industrial combustion plants and fugitive emissions from fossil fuels. A Strategic Environmental Impact Assessment of the Energy Strategy was prepared, and in mid-2019, a public consultation was held on both documents. The Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 was adopted in February 2020 (Official Gazette, No. 25/2020).

In parallel with the development of the Energy Strategy, the development of the NECP began, which provides an overview of the objectives of the Republic of Croatia for each of the five key dimensions of the Energy Union: decarbonisation, energy efficiency, energy security, internal energy market and research, innovation and competitiveness, as well as the appropriate policies and measures to achieve these goals.

In coordination with the development of the Energy Strategy, the NECP and through an iterative approach, an amendment to the Low-Carbon Strategy was carried out. Taking into account the obligations of the Republic of Croatia towards the EU, and other international obligations, the goals of reducing greenhouse gas emissions in the energy sectors have been harmonised. At the same time, the reference and low-carbon scenarios of the non-energy sector (industrial processes and product use, agriculture, waste, land use, land-use change and forestry - LULUCF) were updated.

In parallel with the preparation of the amended White Paper on the Low-Carbon Strategy of the Republic of Croatia, a Strategic Environmental Impact Study of the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050 was prepared, and in the 2nd quarter of 2020, a public consultation on both documents was conducted.

1.3.1. Visions for 2050 and the needs identified by each sector

Low-carbon sectoral visions determine the direction and goal of the development of individual sectors by 2050. Visions of low-carbon development are determined through a process of consultation with the expert and interested public, and are listed in Table 1-1. Through the consultation process, the main needs of the individual sectors for low-carbon development were identified, and they are listed in Table 1-2.

Table 1-1: Visions of low-carbon development of individual sectors until 2050 (result of consultations with stakeholders and the public)

SECTOR	VISION
Power plants (production, consumption, import and export of energy), industry and buildings	In a low-carbon society, we will live and work in low-emission low-energy buildings, with smart heating and cooling systems, i.e. in nearly zero-energy buildings or buildings that have very high energy efficiency. Application of energy efficiency, efficient use of resources, application of renewable energy sources, innovative and new technological solutions, while preserving the security of energy supply. Decentralisation of electricity production, energy consumers will also become energy producers, the use of advanced networks, smart systems and

SECTOR	VISION
	energy storage will allow flexible consumption and strong integration of renewable energy sources.
Transport	We will drive electric and hybrid vehicles, use alternative low-carbon fuels and climate-neutral fuels. In cities, with less use of motor vehicles, we will improve the quality of life in such a way that for most city trips, cars will not be needed at all. Through the development of industries in the segment of sustainable technologies (electric vehicles, charging stations, railway infrastructure), we will drive more in electric and hybrid vehicles, as well as vehicles with a higher share of biofuels, which will signify the transition to low-carbon mobility. There will be more and more autonomous vehicles with smart charging of electric batteries. Sustainable transport systems in larger towns, primarily low-carbon public urban transport, city centres without car traffic, developed bicycle traffic, better fuels and new technologies, will significantly reduce energy consumption and greenhouse gas emissions.
Agriculture	Agriculture will become more attractive to young and educated farmers in restored villages, with diverse crops resistant to climate change. The economies will be economically viable and competitive, with eco-production and green market-oriented cultivation, while respecting agri-environmental measures and the use of agroforestry systems. Rural areas and economies will be nearly energy-neutral and resource efficient. Biomass for fuels will be produced without compromising food production, while proactively contributing to reduced greenhouse gas emissions with negligible environmental impacts. Agriculture with full application of good agricultural practice. Agricultural land and pasture management is carried out in ways that ensure Low-Carbon dioxide emissions.
Land Use, Land Use Change and Forestry (LULUCF)	Land use, land-use conversion and forestry should be such as to permanently represent a CO_2 sink. Forestry will continue the tradition of sustainable forest management. In some forest areas, growth will be increased through silvicultural works (conversions), by converting forests of a low cultivation form into higher cultivation forms, which increases the capacity of carbon sinks in forest biomass. New forest stands will be erected on some uncultivated forest land. Residues of wood biomass from forests and wood production will be used in an environmentally and economically sustainable way. Carbon stocks in forest biomass (wood biomass, soil, hardwood and dead wood) will increase, to make the land use and forestry sector a permanent sink for greenhouse gases. Wood products are a carbon store, with emissions delayed for a long time, depending on the type of product. The use of wood products in traditional and new products will be encouraged. Forestry will have a high level of information on forest condition, inventory, vulnerability and trend projections.

SECTOR	VISION
Waste	By preventing the generation of waste, separate collection, recycling and recovery of waste, the amount of waste for disposal will be reduced to a minimum. All landfills will be rehabilitated, and waste management centres will use advanced technologies which, in addition to obtaining raw materials for material recovery, recycle waste chemically, thus obtaining various chemical compounds that can be used in industrial production (ethylene, ammonia, etc.), as well as various fuels (hydrogen, synthetic gas, liquid fuels). Establishing a waste management system in accordance with the principles of the circular economy will contribute to resource efficiency with less negative impact on people and the environment. A circular economy will keep the value of products, materials and resources in the economy for as long as possible. The use of production processes that consume fewer materials and less energy, use waste-free resources and include full recycling at the end of the product life will be fostered. The design, construction and renovation of buildings will be carried out according to the principles of a circular economy of space and buildings along with the use of resources harmonised with the needs and functionality of buildings. Sustainable resource management and extending the life of materials and products is a key determinant of the transition from an existing linear to a sustainable and competitive low-carbon circular economy.

Table 1-2: Needs of individual sectors for low-carbon development (result of stakeholder and public consultations)

SECTOR	NEED
Power plants (production, consumption, import and export of energy), industry and buildings	• energy independence and sustainability • development of energy equipment and plants • development of the vehicle industry and infrastructure equipment • application of new technologies (consumption management, technologies for the capture and storage of carbon dioxide, new renewable sources, technology for chemical recycling of waste and use of energy derived from waste) • development of the transmission network for the connection of new generation capacities (mostly RES), required for energy self-sufficiency, reception and transmission of electricity produced in RES, and ensuring security of supply and power system with a high share of RES • advanced networks for the purchase of energy produced from renewable sources and for the safety of equipment • clear development strategy and action plans • refinery modernisation and transformation • investing in new activities • investing in research and development of domestic oil and gas deposits • energy renovation of the existing national building stock • construction of nearly zero energy buildings • raised social awareness of energy production in buildings

SECTOR	NEED
Transport	• low-carbon transport (the share of means of transport in the goods transport sector (trucks, ships, trains) and public transport (buses, trams, suburban railways), which use hydrogen cells as fuel, will grow exponentially • a high level of public awareness of public transport and cleaner forms of transport • developed rail and river transport • incentives for vehicles based on lower fossil fuel consumption
Agriculture	• sustainable management of agricultural areas • sustainable and environmentally friendly production • use of mineral fertiliser in accordance with the conditions of good agricultural practice, adequate disposal of organic fertiliser and biogas production, improved manure management system • integrated approach to agricultural development • self-sustainability in food production
Land Use, Land Use Change and Forestry	• in land use change, care will be taken that each land use change reflects the changes in greenhouse gas emissions/sinks • measures to encourage an increase in the amount of carbon in the soil, • increase the value of forests, maintain or improve the existing forest land fund • implementation of afforestation of non-overgrown productive forest land according to forest management plans
Waste	• reduction (avoidance) of waste generation • established waste management system • rehabilitated landfills • complete recovery of waste that includes all levels in the waste management hierarchy and the use of technologies aimed at minimising its disposal

1.4. METHODOLOGICAL APPROACH

In the drafting of the Low-Carbon Development Strategy, a number of scenarios were analysed, numerous models for simulations and optimisations were applied, and an integrated model for national greenhouse gas projections, NUSPCRO, was developed. The added value is that NUSPCRO also allows for the planning of scenarios for other pollutants, so the harmonisation of targets under the obligations of the UNFCCC and the Convention on Long-Range Transboundary Air Pollution (LRTAP) can be carried out simultaneously.

Greenhouse gas emissions and sinks are expressed in this document in accordance with the methodology of the 2006 Intergovernmental Panel on Climate Change (IPCC 2006) and the corresponding greenhouse potential factors for calculating CO_2 emission equivalents. In accordance with this methodology, only emissions that occurred on the territory of the state and emissions from fuels loaded on the territory of the state when it comes to transport are observed. The greenhouse potential (observed over 100 years) to calculate the equivalent amount of CO_2 for the main greenhouse gases is as follows: carbon dioxide CO_2 = 1, dinitrogen oxide N_2O = 298 and methane CH_4=25.

2. SITUATION IN THE REPUBLIC OF CROATIA

2.1. ECONOMIC INDICATORS

After the Croatian economy grew at an average annual rate of 4.3% from 2000 to 2008, which was comparable to the growth of the new EU members, in 2009, a prolonged recession began. In 2014, the real GDP was 12.4% lower than in 2008. The physical volume of industrial production decreased by 17% from 2008 to 2014, and activity in construction recorded an even greater decline.

The economic recovery began in 2015. The GDP growth rate in 2016 was 3.5%, 3.4% in 2017, 2.8% in 2018, 2.9% in 2019, and -8.4% in 2020.

The Croatian economy is in the process of structural transformation from an economy dependent on domestic demand and construction investments, to an internationally competitive, export-oriented economy, in which tourism, the ITC sector and other services play an important role. Better use of European Structural and Investment Funds also contributes significantly to accelerating growth. At the beginning of 2021, a total of EUR 5.36 billion was paid, or 49.94% of the total allocation for the seven-year period (2014-2020), and a significant increase in published tenders and contracted projects was recorded. The efficiency of the use of EU funds is expected to increase in the coming years.

Economic growth and fiscal discipline on the expenditure side of the budget during 2016 halted the growth of the budget deficit and public debt, whose ratios to GDP began to decline. The deficit was below 2% of GDP in 2017 and 2018, and the ratio of public debt to GDP at the end of 2018 was 74.6%. At the beginning of 2020, Croatia, as well as the entire world, faced a pandemic, and the EU planned assistance through the Recovery Fund.

2.2. SOCIOLOGICAL INDICATORS

According to the last Census from 2011, the number of inhabitants in the Republic of Croatia is 4,284,889. The average age in 2011 was 41.7 years.

The Republic of Croatia has been recording very unfavourable demographic trends for many years. Demographic ageing and depopulation are the basic demographic processes in the Republic of Croatia. Croatia is one of the few European countries that has had a declining population for two decades due to negative natural growth, and the emigration of young and professionally educated people due to unemployment and dissatisfaction with their income is becoming a serious problem.

In the Republic of Croatia, large and growing differences between individual regions and micro-regions are becoming more evident. The development index indicates great territorial and development differences. Also worrying is the constant depopulation of rural areas.

2.3. GREENHOUSE GAS EMISSIONS

The inventory of greenhouse gas emissions and sinks is prepared in accordance with the UNFCCC guidelines for annual inventory reporting, which have been adopted by COP (Conference of Parties) Decision 24/CP.19. When preparing the GHG emission calculation, the methodology described in the 2006 IPCC National GHG Inventory was used. According to the guideline, GHG emission sources and sinks are divided into five main sectors: energy, industrial processes and product use, agriculture, land use, land use change and forestry (LULUCF), and waste. The energy sector includes: production of electricity and heat, transport and energy consumption for heating and cooling of buildings.

The calculation covers emissions from human activities, namely direct greenhouse gases: carbon dioxide (CO_2), methane (CH_4), dinitrogen oxide (N_2O), fluorinated hydrocarbons (HFCs and PFCs) and sulphur hexafluoride (SF_6), as well as indirect greenhouse gases: carbon monoxide (CO), nitrogen oxides (NO_X), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2).

2.3.1. Emissions trend

In 2018, total greenhouse gas emissions in the Republic of Croatia, excluding sinks, amounted to 23,792.80 kt CO_2e, which represents a reduction in emissions by 25.36%, compared to greenhouse gas emissions in 1990. The trend of greenhouse gas emissions by sector is shown in Figure 2-1 and Table 2-1.

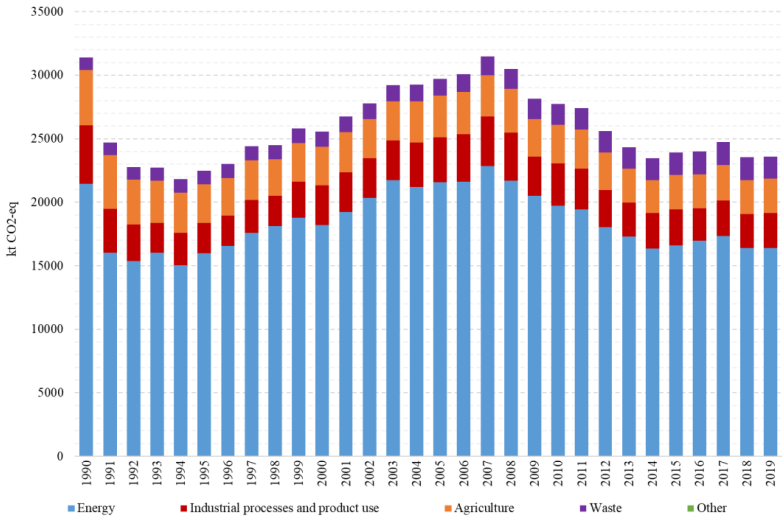

Figure 2-1: Trend of greenhouse gas emissions by sector

Table 2-1: Greenhouse gas emissions/sinks by sector from 1990 to 2018 (kt CO_2e)

Source of greenhouse gas emissions/sinks	Greenhouse gas emissions/sinks (kt CO_2e)						
	1990	2000	2010	2015	2016	2017	2018
Energy (including transport)	21,731.3	18,194.8	19,749.5	16,625.2	17,009.5	17,388.1	16,443.0
Industrial processes and product use	4,669.7	3,132.3	3,317.1	2,823.2	2,489.0	2,738.0	2,590.9
Agriculture	4,423.5	3,042.4	3,056.3	2,722.3	2,678.8	2,805.1	2,720.37
LULUCF	-6,421.4	-6,950.4	-6,926.0	-5,122.1	-5,179.07	-4,489.6	-5,094.2
Waste	1,051.4	1,339.4	1,910.9	1,954.6	2,098.1	2,100.9	2,038.6
Other	NO	NO	NO	NO	NO	NO	NO
Total emissions (including net CO_2 from LULUCF)	**25,454.4**	**18,758.5**	**21,107.7**	**19,003.2**	**19,095.6**	**20,542.5**	**18,698.6**
Total emissions (excluding net CO_2 from LULUCF)	**31,875.82**	**25,708.8**	**28,033.7**	**24,125.3**	**24,275.3**	**25,032.1**	**23,792.8**

The greatest contribution to greenhouse gas emissions in 2018, excluding sinks, was reported by the energy sector with 69.3%, followed by the agricultural sector with 11.2%, industrial processes and product use with 10.9% and the waste sector with 8.6%. This pattern, with minor changes, was retained

throughout the 1990-2018 period. In 2018, the total greenhouse gas emissions in Croatia amounted to 23,792.8 kt CO_2e, excluding sinks (LULUCF sector), while the total emissions with the LULUCF sector included amounted to 18,698.6 kt CO_2e, which is a sink of 21.4% in 2018.

The general decline in economic activities and energy consumption in the period from 1991 to 1994 in the Republic of Croatia, primarily due to the war, caused a decline in total greenhouse gas emissions in this period. Since the entire national economy was in transition at the time, some energy-intensive industries reduced their activities or even stopped production, which had a significant impact on reducing greenhouse gas emissions. Emissions began to grow in 1995, with an average rate of 3% per year until 2008. Due to a decline in economic activity since 2008, greenhouse gas emissions were steadily declining until 2014, when they began to grow slowly.

The biggest reason for the increase in emissions in the period from 1995 to 2008 is the energy sector (electricity and heat production, transport and energy consumption for heating and cooling of buildings), industrial processes and product use (cement production, lime production, ammonia production, production of nitric acid, halogenated hydrocarbon consumption) and the waste sector.

The main reasons for reducing greenhouse gas emissions in the period from 2008 to 2016 are the economic crisis, as well as the beginning of the implementation of measures to reduce CO_2 emissions according to the National Energy Efficiency Action Plan for the period from 2014 to 2016.

The trend of individual greenhouse gas emissions is shown in Figure 2-2.

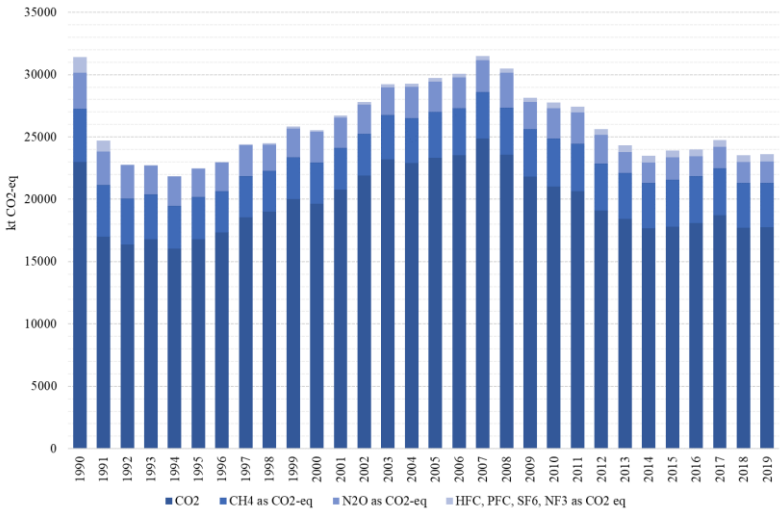

Figure 2-2: Trend of greenhouse gas emissions by gases

The largest contribution to greenhouse gas emissions in 2018 was made by carbon dioxide (CO_2) with 74.5%. It is followed by emissions of methane (CH_4) with 16.3%, dinitrogen oxide (N_2O) with 7.1%, and fluorinated hydrocarbon emissions with 2.1%. The described structure has been present throughout the period since 1990.

2.3.2. Emissions trend with respect to the Emissions Trading System (ETS)

The Republic of Croatia became a party of the EU ETS system on 1 January 2013. The parties of the greenhouse gas emissions trading system were then included in the single allocation plan and the obligation to purchase all or part of the allowances according to the auction model.

The following EU ETS activities are represented in the Republic of Croatia: fuel combustion, mineral oil refining, production of crude iron or steel, production of cement clinker, lime production, glass production, production of ceramic products, production of mineral wool insulation materials, paper and cardboard production, soot production, nitric acid production, ammonia production and aviation. Almost

half of the plants are included in the system based on fuel combustion activities. Other plants are included primarily on the basis of their production activity, although they also use fuel for combustion.

Figure 2-3 shows the total greenhouse gas emissions divided into ETS sectors and sectors outside the ETS.

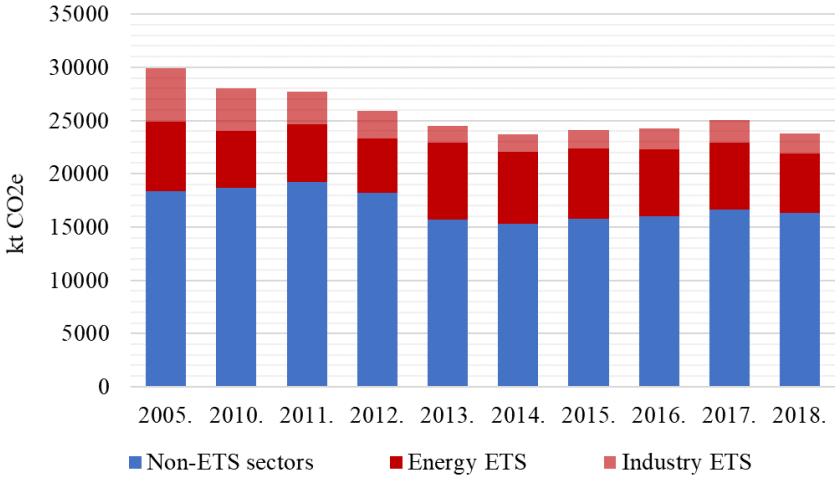

Figure 2-3: Total GHG emissions in ETS and non-ETS sectors

The greenhouse gases covered by the EU ETS represented in the Republic of Croatia are CO_2 and N_2O, of which the latter occurs only as a result of nitric acid production. In 2018, in the Republic of Croatia[2], there were 53 plants included in the EU ETS, and one aircraft operator, which are responsible for 31.3% of the total GHG emissions in Croatia.

2.3.3. Decoupling the trend of economic growth from greenhouse gas emissions

The basic goal of the Low-Carbon Strategy is to decouple the trend of economic growth from greenhouse gas emissions. Figure 2-4 shows the GDP growth, the greenhouse gas emission curve, and the greenhouse gas emission intensity curve as a percentage of the 1995 value.

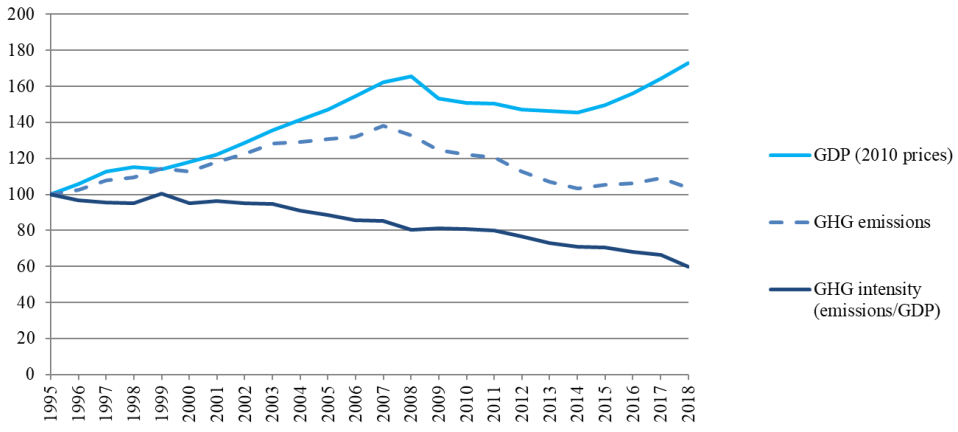

Figure 2-4: GDP trend, greenhouse gas emissions and greenhouse gas intensity curve

[2] 2020 Greenhouse Gas Inventory Report
http://www.haop.hr/sites/default/files/uploads/dokumenti/012_klima/dostava_podataka/Izvjesca/NIR_2020_hrv.pdf

The figure shows the beginning of the decoupling of economic development from greenhouse gas emissions since 2003. The emission intensity per GDP decreased by 34% in the period from 2004 to 2018, i.e. by about 2.5% per year. At the same time, the amount of GDP in 2018 was 22% higher than in 2004, and emissions decreased by 19.6%.

However, the achieved decoupling is only relative, because the reduction in emissions occurred with the fall in the GDP. Through low-carbon development, it is expected that there will be a decoupling of the GDP and emissions, i.e. there will be GDP growth, and a reduction in greenhouse gas emissions.

3. TOTAL GREENHOUSE GAS REDUCTION

3.1. ENVISAGED EMISSION REDUCTIONS UNTIL 2050

The total reduction of greenhouse gas emissions according to the NUR, NU1 and NU2 scenarios is shown in Table 3-1 and Figure 3-1, compared to 1990.

The total emission reductions under the NUR, NU1 and NU2 scenarios, with respect to the ETS-sectors and non-ETS sectors are shown in Table 3-2, compared to 2005.

Indicators of renewable energy sources and energy efficiency in the NUR, NU1 and NU2 scenarios are shown in Table 3-3.

Table 3-1: Emission reduction projections in low-carbon scenarios

Emissions compared to 1990 emissions (%)	**2016**	**2030**		**2040**		**2050**	
	Achieved	NUR	**NU1 to NU2**	NUR	**NU1 to NU2**	NUR	**NU1 to NU2**
Electricity and heat production	-9.9	-42.8	**-49.7 to -53.3**	-53.3	**-65.6 to -79.3**	-56.7	**-61.0 to -93.3**
Fuel production and processing	-55.7	-55.4	**-55.8 to -56.0**	-61.5	**-62.8 to -63.7**	-72.9	**-74.7 to -75.9**
Transport	59.1	63.8	**51.4 to 44.0**	31.7	**20.7 to 16.8**	-1.4	**-28.3 to -55.4**
General consumption sector	-22.3	-22.5	**-30.2 to -34.0**	-26.4	**-40.2 to -53.3**	-33.2	**-55.3 to -73.8**
Industry	-53.9	-51.9	**-54.1 to -57.5**	-53.6	**-58.6 to -64.1**	-56.6	**-64.4 to -83.0**
Agriculture	-36.0	-40.8	**-44.5 to -46.3**	-42.7	**-48.1 to -51.5**	-43.8	**-50.9 to -55.8**
Waste	100.5	35.0	**35.0**	-7.6	**-7.6**	-29.4	**-29.4**
Total projections	-23.5	-28.9	**-33.5 to -36.7**	-37.6	**-44.8 to -50.9**	-46.3	**-56.8 to -73.1**

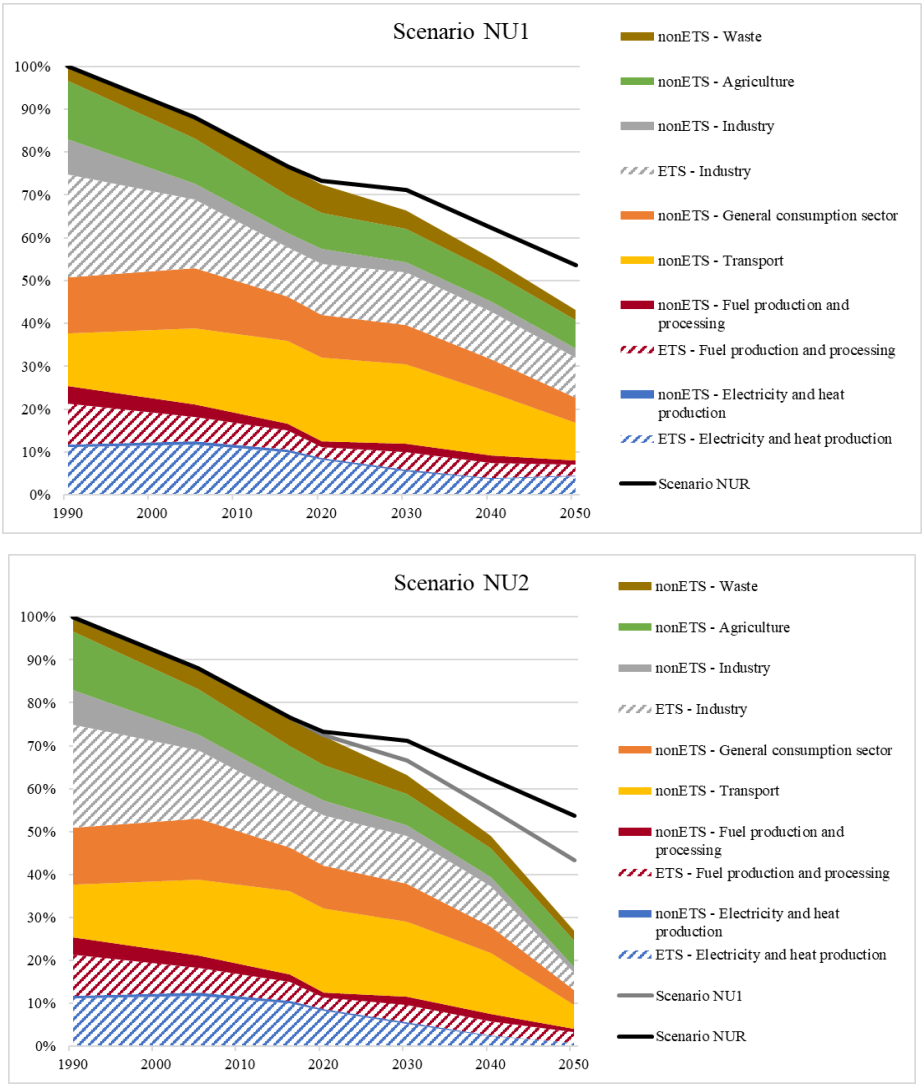

Figure 3-1: Emission reduction projections in low-carbon scenarios

Table 3-2: Emission reduction projections in low-carbon scenarios, ETS and non-ETS sectors

Emissions compared to 2005 emissions (%)	**2016**	**2030**		**2040**		**2050**	
	Achieved	NUR	**NU1 to NU2**	NUR	**NU1 to NU2**	NUR	**NU1 to NU2**
ETS	-22.4	-30.1	**-34.3 to -38.6**	-36.9	**-45.4 to -54.9**	-43.2	**-51.4 to -78.5**
Emissions compared to the 2005 baseline (%)	**2016**	**2030**		**2040**		**2050**	
	Achieved	NUR	**NU1 to NU2**	NUR	**NU1 to NU2**	NUR	**NU1 to NU2**
non-ETS	-8.0	-12.7	**-18.5 to -21.7**	-24.4	**-32.3 to -37.8**	-36.5	**-50.6 to -64.0**

Table 3-3: Renewable energy and energy efficiency indicators in Low-Carbon scenarios

Renewable energy and energy efficiency indicators	**2016**	**2030**	**2040**	**2050**
	Achieved	**NU1 to NU2**	**NU1 to NU2**	**NU1 to NU2**
Share of RES in gross direct energy consumption (%)	28.3	**36.4**	**44.1 to 45.8**	**53.2 to 65.6**
Direct energy consumption (PJ)	277.3	**286.9 to 272.5**	**265.2 to 238.3**	**225.6 to 189.6**
Total energy consumption* (PJ)	359.4	**344.4 to 328.7**	**325.7 to 292.2**	**287.4 to 251.0**

* - total energy consumption without non-energy consumption

The **NU1 scenario** shows a trend of continuously decreasing emissions, so that in 2030, the emissions are 33.5% lower than the emissions in 1990, and in 2050, they are 56.8% lower than the emissions in 1990. With this scenario, Croatia largely fulfils the obligation to reduce emissions to the level set for non-ETS sectors for 2030.

The **NU2 scenario** shows a trend of reducing emissions, very similar to the trend of the NU1 scenario until 2030, in 2030 the emissions are 36.7% lower than the emissions in 1990, and after 2040 the NU2 scenario shows a stronger reduction, so that in 2050 the emissions are 73.1% lower than the 1990 emissions.

Climate neutrality by 2050 compared to 1990 (the so-called net zero emission scenario) is difficult to achieve, according to the current state of knowledge and available technologies. An analysis should be carried out, which would allow for additional measures. Plans for this are listed at the end, in Chapter 15. INFORMATION ON CLIMATE NEUTRALITY SCENARIO.

3.2. TARGETS OF THE REPUBLIC OF CROATIA

Greenhouse gas emission reduction targets are based on the following:

- emission reduction targets arising from the UNFCCC and the Paris Agreement,
- emission reduction targets arising from the internal allocation of the EU, related to non-ETS sectors,
- renewable energy targets and energy consumption reduction targets, based on EU policy,
- benefits of the Republic of Croatia in terms of the principles and objectives set out in Chapter 1.2. of this Low-Carbon Strategy,
- taking into account the existing trend and continuation based on the adopted policies and plans,
- impacts on the economy, the environment and society.

The targets are observed for the period until 2030, and until 2050. The set goals can be achieved by different scenarios that have different effects on the economy, the environment and society.

3.2.1. Targets of the Republic of Croatia until 2030

The Climate and Energy Policy Framework sets out the guidelines for EU action until 2030. The target is set to reduce greenhouse gas emissions by at least 40% compared to 1990. This will be done by reducing emissions in the ETS by 43% compared to 2005, and in sectors outside the ETS by 30% compared to 2005.

It has been determined that the distribution of obligations by country for non-ETS sectors will continue, but no numerical targets for renewable energy sources will be set for each country using a single methodology. Each country decides for itself how it will achieve its goals in sectors outside the ETS, which includes the goals for renewable energy sources.

By 2030, the Republic of Croatia will strive for a more ambitious reduction of emissions, with a trajectory in the area between the low-carbon scenarios NU1 and NU2.

The basic target is set as follows:

- **achieve a 7% reduction in emissions in non-ETS sectors, compared to 2005 emissions. This is the minimum that must be achieved, and it is also a binding target under the European Union and the Paris Agreement, within the common EU target until 2030.**

The targets for renewable energy sources, energy efficiency and sectoral targets derive from the above targets. The implementation document for the period until 2030 is the NECP for the period from 2021 to 2030.

3.2.2. Targets of the Republic of Croatia until 2050

The goal of reducing greenhouse gas emissions by 2050 is:

- **reducing greenhouse gas emissions with a trajectory between the low-carbon scenarios NU1 and NU2, with the aim of a more ambitious NU2 scenario.**

In the period up to 2030, the differences between scenarios NU1 and NU2 are relatively small, but in 2050 these scenarios are very different in terms of the depth of application of measures and the overall reduction of emissions. The Republic of Croatia needs to redefine its low-carbon trajectory at the end of the next ten-year period. Countries whose contribution under the Paris Agreement is determined by 2030 are obliged to communicate or update this contribution every five years, so in 2025, a revision of the targets should be envisaged.

Given the ambitious momentum of the new 2019 European Green Deal and in the context of increasing the EU's common target of reducing EU greenhouse gas emissions to -55% by 2030, adopted by the European Council on 11 December 2020, the next revision of the Low-Carbon Strategy will set the path to achieve net zero greenhouse gas emissions by 2050, and in connection with this, to increase the ambition by 2030. This will follow the amendment and adoption of EU climate and energy legislation when the sectoral and overall targets for the individual Member States are known.

3.3. DEVELOPMENT TREND

3.3.1. Macroeconomic parameters

Population and growth rate of gross domestic product

The number and composition of the population, according to different demographic and socio-economic characteristics, is a fundamental determinant of current and predictable social and economic growth and development. Population is a fundamental factor that changes social, economic, social, cultural, psychological and other conditions of development through its activity. It is particularly important to keep in mind the fact that demographic processes are long-term in nature, both when they are emerging and in terms of future effects. In order to prepare a projection of energy consumption for the purposes of drafting the Energy Strategy, projections of demographic trends for the Republic of Croatia have been created. These projections were also used in analyses of the non-energy sectors.

Assumptions in drafting projections of the demographic trends include:

- Increase in the future total fertility rate in accordance with the latest projection of the UN Population Department.
- Increase in life expectancy for both sexes.
- Slowing down emigration. Zero net migration from 2025 for counties with a high emigration rate, and from 2020 for counties with a low emigration rate.

Actual data on the population of the Republic of Croatia is currently obtained only by the census. When the population register of the Republic of Croatia is established, actual data on the population will be available and it will be possible to follow the trends and form valid projections for the future. Demographic projections take into account not only the natural, but also the mechanical movement of the population. The results of the population projections show a significant decline in the total population. Also, with the decline in the total population, the age structure of the population changes according to the decreasing share of the young (0-14 years) population, the stagnation or slight decline in the working age population (15-64), and a constant share or increase in the elderly population (65+).

Projections of economic trends in the period up to 2050 include projections of gross domestic product (GDP) and gross value added (hereinafter: GVA) of the Republic of Croatia by sector of activity: industry, agriculture, transport, households, services (hotels and restaurants) and other services. The starting year for projections is 2016. Forecast values for GDP are shown in constant prices from 2010 (Table 3-4). A complete description can be found in Annex IV of this Strategy.

Table 3-4: Projection of economic parameters

Economic parameters	**2016**	**2020**	**2030**	**2040**	**2050**
	Baseline productivity				
GDP, constant prices 2010, billion HRK	335.902	373.595	408.987	454.649	520.277
GDP, 2016 index = 100	100.0	111.2	121.8	135.4	154.9
GDP per capita, constant prices 2010, thousand HRK	82	94	109	129	158
GDP per capita, 2016 index = 100	100.0	114.4	132.9	157.1	192.7
Population, in millions	4.099	3.984	3.755	3.532	3.295
Number of employees, constant activity, in millions	1.550	1.559	1.434	1.315	1.191
	Productivity convergence				
GDP, constant prices 2010, billion HRK	335.902	373.595	462.111	551.311	649.695
GDP, 2016 index = 100	100.0	111.2	137.6	164.1	193.4
GDP per capita, constant prices 2010, thousand HRK	82	94	123	156	197
GDP per capita, 2016 index = 100	100.0	114.4	150.2	190.5	240.6
Population, in millions	4.099	3.984	3.755	3.532	3.295
Number of employees, constant activity, in millions	1.550	1.576	1.502	1.429	1.342

The convergence scenario enables the Republic of Croatia to reduce, to some extent, the development gap compared to other EU members, although even this pace does not ensure that it will reach the EU average. According to the convergence scenario, GDP in 2030 is projected to be 37.6% higher than in 2016, and 93.4% higher in 2050. The GDP per capita would amount to HRK 123,000 in 2030 and HRK 197,000 in 2050, compared to HRK 82,000 in 2016.

Fuel prices

Fossil fuel prices by 2050 have been assumed in accordance with International Energy Agency forecasts.

Prices for the period after 2040 have also been extrapolated for the purposes of the analysis reduced to the 2015 euro. Figure 3-2 shows the level of such assumed prices for fossil fuels in EUR/GJ.

For natural gas and coal, prices relevant to the EU area have been entered. A fixed price of 0.74 EUR/GJ is assumed for nuclear fuel, and 4.6 EUR/GJ for biomass.

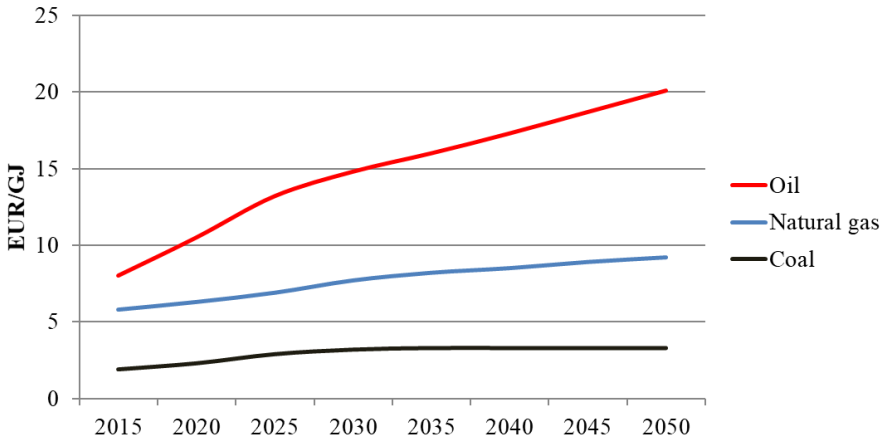

Figure 3-2: Fossil fuel price trend projections until 2050

Electricity market prices

The total electricity needs in the Republic of Croatia are largely provided from imports, and electricity prices are an important input parameter in long-term analyses. It is to be expected that the import trend will continue in the next 5-10 years and will depend on prices, which will grow, and are directly related to the available quantities on the market.

For the needs of the conducted analyses, it was assumed that in the period until 2030, sufficient quantities of electricity will be available to cover the needs of the Croatian electricity system, and that in the long term (until 2050), the total annual net exchange with neighbouring systems will be in balance.

ETS emission allowance prices

The upward trend in emission allowance prices in the EU ETS system was taken from the 2016 EU Reference Scenario. In this model, emission allowance prices are taken as endogenous sizes of system modelling, as a consequence of the trend of the decreasing total of the EU ETS quota (the quota will decrease by 1.74% per year until 2020, then by 2.2% per year until 2030). The price increase is almost constant until 2040, and then increases until 2050. This growth trend should be understood as a strong guideline for individual planning in each investment project.

The basic prices are expressed in euros from 2013. Table 3-5 additionally shows the prices expressed in euros from 2016 (values that are also stated in the EC documents). Current market prices also show higher values than those recommended by the EC. Based on such trends, an alternative price path until 2030, reduced to the 2015 euro, has been estimated. These values were used in the analyses to optimise the electricity generation system (Table 3-5).

Table 3-5: Emission allowance prices in the EU ETS

	2015	2020	2025	2030	2035	2040	2050
EUR'13/t CO_2e	7.0	15.0	22.5	33.5	42.0	50.0	90.0
EUR'16/t CO_2e	7.8	15.5	23.3	34.7	43.5	51.7	93.1
Historical price correction EUR'15/t CO_2e	7.7	25.6	29.9	34.3	43.0	51.1	92.1

3.3.2. Determining the scenarios

A large number of factors determine the preparation and selection of the scenarios; here are some of the most important ones:

- compatibility with existing trends and policies;
- achieving the targets set by the EU for individual Member States: the overall emission reduction target, emission reductions in non-ETS sectors, the share of renewable energy sources and energy efficiency;
- national goals from current strategies and plans by sector;
- availability of technologies;
- costs and benefits;
- meeting the goal of the security of energy supply and strengthening the economy, as well as the other goals set out in Chapter 1.2. of this Strategy.

The scenarios are combinations of different measures with a different 'depth' of application of individual measures. In the scenarios for the period up to 2030, the framework is clearer in implementation, and after 2030, there are many open questions and assumptions. The results relating to the period after 2030 should be accepted through such a prism of observation.

Below are three scenarios that represent the synthesis of a series of analysed scenarios, i.e. they present a wider range of scenarios close to them, which are: the **Reference Scenario (NUR),** the **Gradual Transition Scenario (NU1)** and the **Strong Transition Scenario (NU2).** According to the usual labelling, as reported for the purposes of the UNFCCC, the reference scenario identified here belongs to the category of a scenario With Existing Measures – WEM, and the gradual and strong transition scenarios belong to the category of scenarios With Additional Measures - WAM. Figure 3-3 shows the relationships between the scenarios; schematically, the size of the circle roughly represents the emissions in 2016 and 2050.

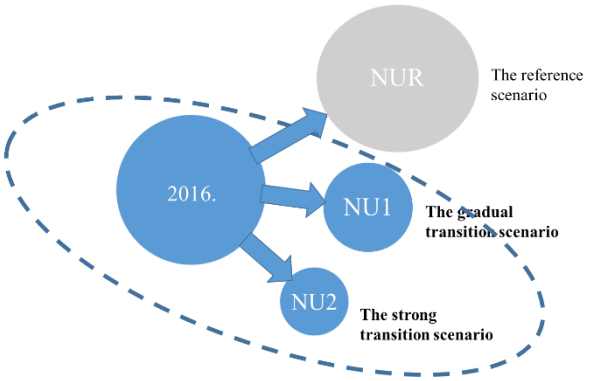

Figure 3-3: Low-carbon NU1 and NU2 scenarios

The reference scenario NUR includes the existing legal framework of the Republic of Croatia and the adopted EU legal framework, as well as a simulation of measures that would be achieved by technological progress without climate change mitigation policies. The reference scenario is not a 'frozen state' scenario, but assumes the development of technologies and their use. Compared to the low-carbon scenarios for achieving the targets, this is a scenario with a slight increase in the share of renewable energy sources and energy efficiency, due to the absence of a strong incentive policy of low-carbon solutions, especially required after 2030. Strategies, plans and programmes that have been adopted and are not yet accompanied by implementing regulations are not included in the reference scenario. The scenario is based in its energy part on scenario S0 from the Energy Strategy. A complete description of the measures can be found in Annex I of this Strategy.

The gradual transition scenario (NU1) is sized to meet the emission reduction objectives that might be obligatory under the EU's internal commitment scheme, and the related international long-term objectives to keep the temperature rise within 2 °C and preferably within 1.5 °C. In this scenario, emission reductions are achieved through the application of a series of cost-effective measures, strong incentives for energy efficiency, and the use of renewable energy sources that could be largely market-competitive in electricity generation after 2030. The scenario assumes a strong increase in the prices of emission allowances, up to 92.1 EUR/t CO_2 in 2050, which is the main driver of the transition. The scenario is based in its energy part on scenario S2 from the Energy Strategy.

The strong transition scenario (NU2) is sized with the aim of achieving an 80% reduction in emissions in 2050, compared to 1990. In this scenario, as well as in the NU1, a strong increase in emission allowance prices up to 92.1 EUR/t CO_2 in 2050, and very strong energy efficiency measures are assumed. The scenario is based in its energy part on scenario S1 from the Energy Strategy.

The **net zero emissions scenario (climate neutrality)** is included in this document in the form of information, as policy decisions at EU level in this direction have been taken recently. At the end of 2018, the document *A Clean Planet for all – A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy* was adopted. The purpose of this long-term strategy is to reaffirm Europe's leading role in shaping global climate policy, and present a vision that can help to achieve a net zero greenhouse gas emission rate by 2050, in a cost-effective way and through a socially just transition. At the end of 2019, the EU set a new strategic framework - *the European Green Deal*, which bases economic progress on a climate-neutral economy until 2050. At the end of 2020, a new EU target until 2030 was adopted, a reduction in net emissions of 55% compared to 1990. In the coming years, through intensive analyses and discussions, Member States will analyse possible net zero emission scenarios until 2050, revise the targets until 2030, as well as their low-carbon strategies, which also applies to the Republic of Croatia.

4. ENERGY FROM RENEWABLE SOURCES

In the energy policy of the EU and the Energy Union, one of the main goals is to increase the share of renewable energy sources, which has a positive impact on reducing dependence on energy imports, reducing greenhouse gas emissions in electricity and heat production, organic waste management, efficient heating through cogeneration plants and opening a new niche in the service and industrial sector related to technological development of renewable energy plants, which ultimately contributes to an increased employment rate.

The national target for energy from renewable sources by 2020 is set by Directive 2009/28/EC and the Treaty of Accession of the Republic of Croatia to the EU, at 20% of the energy share from renewable sources in gross direct energy consumption. The calculation of the target is based on the energy share from renewable sources in gross direct consumption in 2005, which was determined as 12.6%. Following corrections in energy balance due to the survey on higher biomass consumption in the

household sector (Central Bureau of Statistics, 2015), the historical data set was changed and according to such data it was calculated that the energy share from renewable sources in 2005 was 23.8%. Based on the adjusted share for energy from renewable sources in 2005, the indicative target for the energy share from renewable sources in gross direct energy consumption for the Republic of Croatia in 2020 was 28.6%.

Within the framework of the EU climate and energy policy, a common goal is defined at the EU level by 2030 in the amount of 32% of the energy share from renewable sources in gross direct energy consumption. In accordance with the undertaken obligations, the Republic of Croatia will strive to achieve the goal of 36.6% share of energy from renewable sources in gross direct energy consumption by 2030.

In all scenarios, the energy share from renewable sources is increasing. In the period until 2030, the expected share of energy from renewable sources is 36.6%, which is a higher target than the EU one, which will allow the use of additional mechanisms from the Regulation amending the Regulation establishing a guarantee of origin of electricity (Official Gazette, No. 55/2019), such as the possibility of exporting green energy certificates from renewable sources. The increase in the energy share from renewable sources is a consequence of an increase in the share of electricity consumption, an increase in the production of electricity from renewable sources and a decrease in total energy consumption.

In the period until 2040, the expected energy share from renewable sources, depending on the scenario, is from 44.1 to 45.8%, while in the period until 2050 the expected energy share from renewable sources is at the level of 53.2% to 65.6% (Table 4-1).

Table 4-1: Energy share from renewable sources in gross direct energy consumption

	NU1 SCENARIO (%)			**NU2 SCENARIO (%)**		
Energy share from renewable sources in gross direct energy consumption	2030	2040	2050	2030	2040	2050
	36.6	44.1	53.2	36.6	45.8	65.6

5. ENERGY EFFICIENCY

The Republic of Croatia defined national goals for increasing energy efficiency by 2020, in the 3rd National Energy Efficiency Action Plan for the period 2014-2016 and it was revised in the 4th National Energy Efficiency Action Plan for the period 2017-2019. The indicative national goal for increasing the energy efficiency of the Republic of Croatia, expressed as the absolute amount of direct energy consumption in 2020, is 281.7 PJ. The corresponding goal expressed as the absolute amount of primary energy in 2020 was 333 PJ.

Increasing energy efficiency is the most important mechanism for reducing energy consumption and is one of the fundamental principles of energy transition. Increasing energy efficiency is necessary to ensure energy affordability. It is envisaged to increase energy efficiency in all areas of consumption and in the entire chain from production, transmission and transport, distribution and consumption. All methods of reducing consumption will be applied, from legislation, application of standards and norms, replacement of plants and devices to the ban on the use of inefficient devices.

In addition to sector-specific measures, the development scenario also takes into account the effects of regulatory measures that will have cross-sectoral effects. First of all, this refers to the establishment of a functional system of energy efficiency obligations for energy suppliers, in accordance with the current legislative framework of the EU and the Republic of Croatia. This mechanism is expected to make great

progress in improving energy efficiency in all sectors of direct consumption through innovative market mechanisms that engage private capital, both of suppliers and of other participants in the energy services market.

Energy transition means increasing energy efficiency of the entire energy chain, including production, transmission, distribution and direct consumption of energy. The greatest effects are expected in buildings and transport, and the consequences are:

- energy renewal, with a gradual increase in the renewal rate in the period 2021-2030 from 1.0% to 3.0%, and 3.5% from 2031 to 2040, 4% from 2041 to 2050, as determined by the Long-Term Strategy for the Renovation of the National Building Fund until 2050
- increase in share of electric and hybrid vehicles, which in road traffic, depending on the scenario NU1 and NU2, will reach from 3.5% in 2030 to 85% in 2050.

Framework goals of the Republic of Croatia for the period until 2030 and 2050, expressed in absolute values of primary and direct energy consumption, according to the EU Directive on Energy Efficiency, are indicated in Table 5-1.

Table 5-1: Framework national goals of energy efficiency

	2020	**NU1 SCENARIO (PJ)**			**NU2 SCENARIO (PJ)**		
		2030	2040	2050	2030	2040	2050
Primary energy consumption	333	344.4	325.7	287.4	328.7	292.2	251.0
Direct energy consumption	281.7	286.9	265.2	225.6	272.5	238.3	189.6

Increasing energy efficiency will benefit the environment, reduce greenhouse gas emissions, improve energy security, reduce energy costs and mitigate energy poverty. This will lead to greater competitiveness, increased employment and increased economic activity, which will improve the quality of citizens' life.

6. LOW-CARBON DEVELOPMENT SCENARIOS BY SECTORS

This chapter provides an overview of policies and measures and guidelines for implementing the Low-Carbon Strategy. The measures are described by individual sectors. A complete list of measures can be found in Appendices I, II and III of this Strategy. Based on the identified possible measures, their combination defines the scenarios. The following criteria were selected as the main criteria for selection of measures and depth of their implementation: cost efficiency, employment potential, raising the competitiveness of domestic industry and local development.

The Low-Carbon Strategy sets out two Low-Carbon scenarios: the gradual transition scenario (NU1) and the strong transition scenario (NU2). These two scenarios define the framework for the future and depending on circumstances, the path should be between these two ‘borderline’ scenarios. Europe's new policy commitments announced in late 2018, with a vision of a society with net neutral greenhouse gas emissions in 2050, clearly indicate that the NU2 scenario should be pursued as much as possible, given that even more ambitious goals will need to be considered very soon.

The Low-Carbon Strategy provides a framework for action by sector and vertically, from the state level to action at the local level. It does not consider individual projects, investments and decisions, unless they are already recognized as strategic. From the general guidelines, benchmarks, criteria and scenario factors NU1 and NU2, investors and decision makers need to identify the desired direction. Due to its

long-term nature, it must be broad enough to cover possible geopolitical and other circumstances beyond the control of the Government of the Republic of Croatia and economic entities.

With these scenarios, the Republic of Croatia achieves a 33.5 to 36.7% reduction in emissions in 2030 compared to 1990, and in 2050 56.8 to 73.1%.

The NU2 scenario is set ambitiously, with an 80% reduction in total emissions compared to 1990. The analysis showed that reducing emissions by over 73.1%, as far as the Croatian NU2 scenario is concerned, would require the implementation of very expensive technical measures or much larger emission reductions in the agricultural sector, which could have major socio-economic consequences. It is very likely that the development of new technologies will allow this difference to be realized more cost-effectively over time.

Time horizon

2021 - 2030 The implementation of measures in this period should be strong, it is a period in which the Republic of Croatia is turning towards the path of Low-Carbon development. Emission prices are expected to be quite high towards the end of this period, and awareness of the need to reduce emissions and the impacts of climate change at the collective and individual levels is developed. In this period, the Republic of Croatia will decide whether to go in an even more ambitious direction after 2030. Globally, under the Paris Agreement, agreements to increase ambition are in five-year cycles. In this regard, there is a new way of managing climate change policy at EU level (new governance), dialogue will overcome normative approaches, and this approach will spread vertically through society and the economy, as a sociological novelty. In this period, strong logistical support for the transition should be an operational program for climate change mitigation and adaptation, funded through EU structural funds.

2031 - 2050 This period should be observed in the possible range of action between NU1 and NU2 scenarios. The international context, economic development and technology development will determine the direction. Awareness of the need for ambitious action will be built at all levels.

6.1. ELECTRICITY AND HEAT PRODUCTION

6.1.1. Greenhouse gas emissions

The electricity and heat production sector in 2018 accounted for 13.8% of the Republic of Croatia's greenhouse gas emissions, and 96% of the emissions in this sector were covered by the ETS.

Compared to 1990, in this sector in the Low-Carbon scenarios NU1 and NU2, emission reductions are achieved by 49.7 to 53.3% in 2030, and by 61.0 to 93.3% in 2050.

6.1.2. Policies and measures for Low-Carbon development

There will be major changes in this sector, fossil fuel power plants will give way to renewable energy sources. Of the fossil fuel power plants, high-efficiency gas cogeneration plants will be of the greatest importance. The direction is towards decentralization of electricity production, consumers (households and institutions) will also be energy producers, energy exchange will take place at local levels, and energy producers and energy storage will be connected by advanced networks. Flexible consumption will be managed by smart systems. For the integration of renewable energy sources, energy storage tanks, their capacities, charging and discharging speeds and the price of technologies will be crucial.

Electricity consumption is expected to increase due to the electrification of the transport sector, the increase in the use of heat pumps for heating, the increase in the use of air conditioners and economic development in the industry and service sectors. The additional growth of gross electricity consumption will be influenced by the development of electric boilers and/or heat pumps in district heating systems and in the long run the potential development of hydrogen electrolysis systems, which will use electricity in times of low prices or excess electricity production from renewable sources.

On the other hand, there is significant potential for saving electricity and increasing energy efficiency in direct consumption, primarily by increasing the efficiency of household and office appliances, increasing the efficiency of public and indoor lighting systems, applying energy efficiency measures in industry and replacing electric heating with more efficient systems.

Basic measures include the use of renewable energy sources and cogeneration, the use of fuels with lower specific CO_2 emissions, increased energy efficiency, CO_2 capture and storage, the use of nuclear energy and the reduction of losses in energy transmission and distribution.

Renewable energy sources (RES) and cogeneration. The measure includes construction of plants using renewable energy sources to produce electricity and/or heat, such as hydropower, solar, wind, biomass/biogas and geothermal power plants.

It is assumed that all options for electricity generation are open and have equal access to the market (without any kind of incentive for any technology). The possibilities of using certain forms of energy are determined in accordance with the assessment of the available potential and available technologies. The following options are considered:

- **hydropower plants**
  - accumulation, once-through and reversible
  - small power plants (usually connected to distribution network)
- **solar power plants**
  - photovoltaic systems - individual/integrated and at the level of distribution and transmission network. Preference is given to systems that are integrated, i.e. located at the point of immediate consumption
  - (CSP - Concentrated Solar Power)
- **wind farms**
  - on land and over the sea (offshore)
- **power plants/cogeneration using solid biomass and biogas, hydrogen, synthetic gas and other fuels obtained by chemical recycling of waste**
  - synthetic gas obtained by chemical recycling of waste can be used in existing natural gas fired power plants
- **geothermal power plants.**

Energy storage tanks (batteries). Energy storage is necessary in systems with a high share of volatile renewable energy sources (sun and wind), because it allows the use of stored energy in periods of lower availability of renewable energy. In addition, the use of energy storage systems delays and reduces the need to build new power plants, because the stored energy is used during periods of increased system load. Also, energy storage systems will play an important role in supporting the production of electricity for their own needs and enable small producers to make greater use of the energy they have produced themselves. The need to build an energy tank (battery) to balance the system is particularly pronounced after 2030.

District heating system (DHS). When considering DHS, cogeneration systems and their improvement with heat storage technologies at times when electricity is cheap are considered to be the framework. Adequate heat storage tanks can be added to all locations that have needs for thermal energy, especially in gas or biomass cogeneration plants, which have the possibility of rapid changes in the electricity and heat production.

Use of fuels with lower specific CO_2 emissions. Fuel replacement in existing electricity and heat production plants.

Oil-fired power plants. The existing oil-fired power plants will be out of operation by 2025. These power plants are already not used in regular operation today because they cannot compete with other options on the market due to their high production costs.

Coal-fired power plants. The main price signal for less investment in new coal-fired power plants is the price of electricity on the market and the price of emission allowances, which means that coal-fired power plants cease to be sufficiently competitive, despite the relatively cheap energy source. The Low-Carbon Strategy does not envisage the construction of new coal-fired power plants. Existing thermal power plants can maintain their competitive position, but in the final years of their technical life, engagement could be greatly reduced.

Natural gas fired power plants. Natural gas is a very important energy source in transition to systems with high proportions of variable RES, due to its presence in cogeneration plants and participation in regulation of the electricity system. However, in scenarios with projected growth in energy and emission prices, the expected operating hours of gas fired power plants are below the financially desirable commitment, and the profitability of these investments becomes strongly linked to ancillary regulatory services. Gas units are used to secure system reserves, due to low specific investment costs, construction speed and response speed in case of engagement. Locations of existing power plants where individual units are decommissioned can be used for construction of new units, given that they already have certain infrastructural prerequisites.

CO_2 capture and geological storage technology. The Republic of Croatia has technical and natural prerequisites for use of carbon capture and storage (CCS) technology. The development of CO_2 capture and geological storage systems is now seen as a transitional solution, which in the next 3-4 decades should allow the continued use of fossil fuels with a share in total electricity production, while gradually reducing greenhouse gas emissions, until technological and organizational conditions for Low-Carbon development are achieved. The NU1 scenario is achievable without CCS, and in the NU2 scenario there is a need for CCS on gas fired power plants and the cement industry in the years after 2040.

Nuclear power plants. It is predicted that the Krško Nuclear Power Plant (NPP) will operate until 2043. Simulations show that by 2043, the Krško NPP, without CO_2 emissions, will deliver more energy to the system of the Republic of Croatia than the production of all thermal power plants combined, and about fifty percent of the total energy produced from solar power plants and wind. In Low-Carbon scenarios, it is conservatively assumed to decommission the Krško NPP plant by 2043.

6.1.3. Guidelines for Low-Carbon development

<u>By 2030</u>

- Electricity producers that will continue to use fossil fuels for some time should take into account the expected increase in emission allowance prices in their planning. Free allowances will only be given to heating plants, in terms of heat supply for households and services.
- If a path to a Low-Carbon economy is decided in the period up to 2030, in the direction of the NU2 scenario after 2030, which means wider application of CCS technology, all existing and new fossil fuel power plants will need to examine the possibility of applying CCS technology.
- Analyse innovative RES incentive models, especially through RES civil energy models and develop a development program appropriate to Croatian circumstances, with the aim of developing RES projects with greater participation of local population in ownership, management and revenue, to expand the benefits of RES incentives.
- It is necessary to continuously plan the development and construction of the electricity network for integration of renewable energy sources, the development of decentralized and centralized electricity storage, the expansion of advanced networks and smart systems. Regarding the integration of renewable energy sources, the market value of the available reserve power in the system of conventional power plants should be adequately evaluated in order to enable investments in such sources.
- Development of integrated systems projects and multi-purpose solutions for electricity generation, water regulation, agri-environmental measures, tourism and other purposes should be evaluated through general social benefits (cost-benefit analysis) and in this regard decide on

forms of incentives. The start of the use of funds from the Modernization Fund is in accordance with the Act on Climate Change and Ozone Layer Protection. This is an opportunity for public-private partnership and funding from different funds with synergy of action.

- It is necessary to continuously work on the assessment of the potential of renewable energy sources, mapping of potentials, and especially the potentials of biomass and relations with the LULUCF sector should be processed urgently and in detail.
- A program to use the potential for efficiency in heating and cooling for the period 2021 to 2030 should be implemented.
- It is necessary to continuously analyse the situation and, if necessary, improve the models in order to enable the development of RES projects with participation of the local population, in terms of ownership, management and revenue. The model of stimulating electricity production is moving from the "feed-in" principle to the premium approach by which the price is determined through competitive bidding. Towards the end of the period until 2030, it is anticipated that there will be no more incentives for electricity generation, first for wind farms and PV systems.
- Development of mechanisms for continuous updating of the tariff system for regulatory services in electricity production, which should maintain healthy competitive market conditions for various technological solutions.

By 2050

- Electricity will become prevalent form of energy.
- Building new renewable energy capacities implies adequate development of electricity network for integration of renewable energy sources, development of decentralized and centralized electricity storage, expansion of advanced networks and smart systems and stronger integration with e-transport sector and heating systems.
- Power plants/cogeneration plants using solid biomass and biogas, hydrogen, synthetic gas and other fuels obtained by chemical recycling of waste can become competitive

6.2. FUEL PRODUCTION AND PROCESSING

6.2.1. Greenhouse gas emissions

This section combines three sectors according to the IPCC methodology: refineries, solid fuel production sector and other energy industry, and fugitive emissions (emissions from a number of small sources or areas - evaporation, leakage, etc.).

The oil and gas production and refining sector accounts for 7.4% of the Republic of Croatia's greenhouse gas emissions (2018), of which 74.6% are emissions from refineries. From this sector, 74.3% of emissions are covered by the ETS. This refers to emissions from fuel combustion.

Fugitive methane emissions from production, transport and distribution of fossil fuels are calculated in the special fugitive emissions sector and account for an additional 1.7% of total emissions. Fugitive emissions are not covered by the ETS.

In this sector, in the NU1 and NU2 scenarios, the emission reduction is achieved from 55.8% to 56.0% in 2030 and from 74.7% to 75.9% in 2050, compared to 1990.

6.2.2. Policies and measures for Low-Carbon development

Oil and oil products

In the upcoming period of the decarbonisation policy of the energy sector, the oil sector will be strongly influenced by the increase in the use of alternative fuels, but also by the increase in energy efficiency and the consumption of petroleum products will continuously decrease. This will particularly affect the

operation of refineries, the transport and distribution of oil and petroleum products, and the storage market.

Regardless of the projected reduction in the consumption of petroleum products by 2030 and 2050, respectively, they will still occupy a significant share in total energy consumption and it is necessary to ensure their uninterrupted supply. The Energy Development Strategy determined that due to reduction of the supply of domestic oil production, it is economically and energetically justified to encourage additional investments in existing production capacities and new research and to accelerate the completion of modernization and/or transformation of refineries in order to increase competitiveness.

Annual production of petroleum products, according to Low-Carbon scenarios, will be approximately at the level of today's production until 2030, followed by a gradual decline in production. The decline in production after 2030 was caused primarily by an increase in the number of electric vehicles and alternative fuel vehicles in road transport.

The production of petroleum products will be accompanied by a reduction in the consumption of derivatives until 2035. After 2035, there will be a decrease in the consumption of petroleum products and an increase in net exports.

Regardless of the projected reduction in oil refining in the region's refineries after 2030, there will be no reduction in oil transport in the conditions of further diversification of routes and sources of supply to refineries in the countries of Southeast and Central Europe.

Refineries and biorefineries. Significant investments are required in modernizing and improving production in order to maintain the competitiveness of refineries. However, it is important to consider business diversification models in cases where investment is not justified.

The development of technologies for energy production from biomass is mostly focused on transport sector, for production of advanced biofuels through a system of biorefineries.

A system of incentives for research activities is required in order to develop technologies for obtaining advanced biofuels.

Natural gas

The development of the gas system in the Republic of Croatia is conditioned by the development of the gas market and the need to ensure an appropriate level of gas supply security. It is necessary to ensure internal operational security of gas supply, as well as security of gas supply. At the moment, the Republic of Croatia is supplied with gas from domestic production and imports through supply routes from Slovenia and Hungary, and the peak demands are met by the supply from the underground gas storage Okoli.

The Republic of Croatia is currently recording a declining trend in domestic production of natural gas.

Further development of the gas transmission system of the Republic of Croatia is necessary in order to increase its technical security, security of supply, market adaptability and efficiency. Therefore, in addition to the need for the gas transmission system, with its capacities and connection to several sources and directions of natural gas supply, to enable uninterrupted supply and in extraordinary conditions, the system must enable supply at market competitive prices.

The development of the natural gas storage system includes the upgrade of the existing underground gas storage, construction and commissioning of a new (peak) underground gas storage and the potential construction of a new seasonal gas storage in accordance with the possibilities and needs.

Liquefied natural gas terminal. The construction of a liquefied natural gas (LNG) terminal is one of the strategic projects of the Republic of Croatia. The main purpose of the LNG terminal is to receive

special LNG ships, to transfer LNG into tanks, to store, evaporate and deliver natural gas to the gas network and to distribute gas in ship traffic (bunkering).

LNG Hrvatska d.o.o. company was established with intention of building and managing the infrastructure needed to receive, store and gasify LNG. The LNG terminal is located in the municipality of Omišalj on the island of Krk. The project is an important factor in diversifying natural gas supply and increasing security of supply in Central and Southeast Europe.

The size of the LNG terminal depends on market interest, and in the first phase a FSRU (*floating storage and regasification unit)* was built, with a maximum annual natural gas supply of up to 2.6 billion cubic meters. The planned maximum capacity of natural gas delivery from the terminal, and indirectly its size and capacity, is conditioned by the maximum capacity of the gas pipeline system.

The LNG terminal was put into operation in January 2021.

6.2.3. Guidelines for Low-Carbon development

By 2030

- Reduced demand for liquid fossil fuels in refineries could lead to excess refinery capacity and increased international competition - efficiency and optimization of refinery operation is important; in order to maintain competitiveness.
- Increase in consumption of liquid biofuels potentially opens the opportunity for existing refineries to expand their activities to advanced biofuels - it is necessary to conduct additional analyses of possibilities and cost-effectiveness of such projects. Also, it is necessary to consider the expansion of storage capacity, which must follow the increase in biofuel consumption.
- Analyse the possibility of hydrogen and synthetic fuel production in the context of power system regulation and use in gas system and transport.
- Given the high potential for global warming and the relatively short lifetime of methane in the atmosphere, special attention will need to be paid to this issue, once a common methane strategy has been adopted at EU level.

By 2050

- It is necessary to encourage the integration of measures to reduce emissions from flares (methane regeneration, installation of flares with high efficiency and separation of produced CO_2).
- Measures to completely prevent deaeration should be encouraged.
- Measures to minimize gas leakage during distribution should be encouraged.
- In the scenario of implementing measures to reduce emissions in transport, a trend of decreasing demand for liquid fossil fuels can be expected - the survival of refineries will depend on international competitiveness and the ability to develop new activities such as biofuels, hydrogen or synthetic fuels.

6.3. TRANSPORT

6.3.1. Greenhouse gas emissions

In 2018, traffic accounted for 27% of total greenhouse gas emissions, of which road passenger transport 71.6%, road freight transport 24.7%, rail transport 0.8%, maritime and river transport 2.4% and domestic air traffic 0.5%. In 2018, the transport sector had a higher emissions than in 1990 by 60.4%. About 90% of domestic air transport emissions are covered by the ETS, i.e. less than 0.4% of emissions from transport sector.

In the Low-Carbon scenarios NU1 and NU2, compared to 1990, despite the measures in 2030, emissions are still higher than in 1990 by 51.4% and 44% in 2030, respectively, because traffic will have increase

in emissions until 2018. Emission reductions from 1990 levels are not expected until after 2040. In 2050, the decrease in the NU1 scenario will be 28.3%, and in the NU2 scenario 55.4%.

6.3.2. Policies and measures for Low-Carbon development

Basic traffic measures include:

- the use of low-CO_2 fuels, which includes the use of electric and hybrid vehicles, vehicles using natural gas and biogas, liquefied petroleum gas, vehicles using hydrogen and the use of biofuels,
- optimization and increase of transport efficiency,
- discourage diesel fuel consumption and import of old diesel vehicles,
- promoting sustainable integrated passenger and freight transport,
- localization of production and consumption in order to reduce freight traffic.

Alternative fuels. Use of alternative fuels in transport, such as electricity, liquefied natural gas (LNG), compressed natural gas (CNG), liquefied petroleum gas (LPG), biofuels, hydrogen, synthetic gas obtained by chemical recycling of waste. A prerequisite for the implementation of the measure is the development of infrastructure for alternative fuels and encouraging the replacement or purchase of new vehicles.

Electrification of personal vehicles. The development of vehicles that use electricity (including hybrid vehicles) will be very important for a strong reduction of emissions in the transport sector by 2050. For effective overall emission reductions, it is important to support this measure with measures to reduce emissions in electricity generation, i.e. the use of RES. In the electrification sector of transport systems, in the development of infrastructure, but also vehicles or vehicle components, there is an opportunity for innovation and domestic industry.

Natural gas, synthetic gas and biogas. Increase in use of natural gas, synthetic gas and biogas in buses, light and heavy goods vehicles, rail and maritime transport. In parallel with the development of eco-shipping, it is necessary to develop fuel collection facilities for gas and eco-ships such as filling stations and plants for liquefied natural gas, compressed natural gas, liquefied petroleum gas, hydrogen and synthetic gas.

Hydrogen. The potential of hydrogen as a fuel is significant. Significant investments are needed in the hydrogen distribution network, which has been identified as one of the key means towards the wider adoption of hydrogen as a fuel for transport, while the availability of hydrocarbons is not considered an obstacle. The use of hydrogen in vehicles does not require special adjustments in terms of travel and vehicle charging habits. Although technologies for hydrogen production already exist today, considerable efforts are needed to establish the infrastructure for filling vehicles with hydrogen. The advantage of hydrogen is that due to its high energy value it is suitable for use in trucks and for propulsion of ships. Its widespread use helps in the integration of renewable energy sources because surplus electricity from renewable sources can be stored so that hydrogen is produced.

The use of biofuels must in future be limited to advanced biofuels that are produced in a way that does not jeopardize agricultural production in accordance with sustainability criteria. The development of biofuels will depend on sustainability criteria and innovations and solutions for advanced biofuels, as well as on the incentive system.

Promoting sustainable integrated transport. The successful promotion of sustainable integrated urban and interurban transport with an emphasis on the development of rail for passenger and freight transport will be followed by the transfer of freight and passenger transport from road to rail and inland waterways.

Economical fuel consumption. Improving vehicle efficiency during fleet renewal will be the first factor to reduce unit greenhouse gas emissions based on existing EU policies and measures. The most

significant measure is the commitment to reduce average emissions for all new passenger cars below 95 g CO_2/km from 2021.

Sustainable transport systems in cities. Priority is given to Low-Carbon public urban transport, the very centre of cities without traffic, developed bicycle transport, more energy-efficient fuels and new technologies, will significantly reduce energy consumption and greenhouse gas emissions. More and more vehicles in public transport will be autonomous vehicles with advanced charging and battery use. The development of intelligent and integrated urban transport systems includes the optimization of urban freight transport logistics, intelligent traffic management and public parking areas, the introduction of car sharing systems and the promotion, development and optimization of public urban passenger transport.

Reduction of emissions in freight transport. Freight transport is expected to increase, in intercity and city traffic. A very important measure should be to increase the use of rail transport, in general the transport system should be better optimized, by applying ICT solutions and using autonomous vehicles where possible. Fuels produced with the help of electricity from renewable energy sources are suitable for road trucks, and the most promising fuel is hydrogen (use in fuel cells), synthetic methane and synthetic liquid fuel. Smaller trucks will be hybrid and battery powered. For ships in transition, the alternative fuel is liquefied natural gas, followed by hydrogen and synthetic fuels.

6.3.3. Guidelines for Low-Carbon development

By 2030

- Capacities for sustainable mobility planning and integrated urban mobility planning need to be strengthened in transport sector.
- The development of integrated transport needs to be encouraged. Rail transport needs to be encouraged in order to become competitive with other modes of transport. One of the preconditions for realization is to improve the infrastructure:
    - railways (including electrification), signalling and control systems need to be upgraded and modernized to allow for higher traffic speeds;
    - it is necessary to invest in the renewal of the stock of locomotives and wagons;
    - it is necessary to develop a network of logistics intermodal platforms, with these platforms to be built in ports and major consumer centres. The same is necessary due to the inclusion of the origin of supply chains in Croatian ports that compete with other ports in this area;
    - it is necessary to connect public city and intercity transport systems;
- Systematic work is needed to improve inland waterways in terms of organization, fleet modernization, education, infrastructure construction (waterways and ports), maintenance and safety of navigation, as well as improving cooperation with neighbouring countries. Possibilities for widening inland waterways need to be explored;
- It is necessary to invest in the development of intelligent and integrated urban and public transport systems, which include the development of urban cycling infrastructure, optimization of urban logistics in freight transport, intelligent management of public transport and parking areas and encouraging technical innovations in urban transport. It is particularly important to ensure the development of infrastructure and opportunities for the use of alternative fuels in public transport;
- It is crucial to provide infrastructure for alternative fuels, with an emphasis on urban areas in order to encourage the use of alternative fuels primarily in public urban transport;
- It is necessary to continue to systematically conduct promotions and campaigns to encourage the transformation of opinions and actions of residents in the direction of using modes of transport that reduce greenhouse gas emissions.

By 2050

- Continue with activities depending on the success of development by 2030. The continued use of alternative fuels for passenger cars will be crucial. It will be necessary to continue with the processes of development and improvement of integrated railway and river transport as a very important factor for reducing emissions and increasing the competitiveness of the economy;
- Information technology will be of great importance for optimizing transport systems and integration with power system;
- The use of alternative fuels and integrated urban transport, which includes public urban transport, intelligent freight transport systems and developed cycling infrastructure, will be very important in order to almost completely eliminate greenhouse gas emissions from urban areas;
- Alternative fuels will be needed to reduce emissions in heavy goods vehicles, in particular the use of hydrogen using fuel cells, and the use of synthetic gaseous and liquid fuels. Transport systems should be highly optimized by applying ICT solutions and using autonomous vehicles where possible.

6.4. GENERAL CONSUMPTION SECTOR

6.4.1. Greenhouse gas emissions

Emissions in the general consumption sector (households, services and energy consumption in agriculture, forestry and fisheries) in 2018 accounted for 13.5% of total emissions, of which 58.1% related to households, 18.7% to the services and 22.1% on emissions from fuel combustion in agriculture, forestry and fisheries. Despite the relatively low contribution of this sector from the point of view of emissions, its impact on the energy system and the potential for energy savings is great. Energy consumption in the general consumption sector in 2018 amounted to 144 PJ, i.e. 50.3% of direct energy consumption, i.e. 35.3% of total energy consumption in the Republic of Croatia.

Compared to 1990, in the low-carbon scenarios NU1 and NU2, this sector reduces emissions by 30.2 to 34% in 2030 and by 55.3 to 73.8% in 2050. It is the sector that is most strongly regulated in terms of standards, but also most strongly dependent on changes in behaviour.

6.4.2. Policies and measures for Low-Carbon development

In the general consumption sector, there is great potential for energy savings and thus reduction of emissions, primarily through:

- decarbonisation of the national building stock, through energy renovation of residential and non-residential buildings, with directing the renovation towards in-depth renovations and nearly zero energy buildings (nZEB), the standard set for renovation;
- replacement of the demolished part of the fund with almost nearly zero energy buildings;
- replacement of existing household appliances, office equipment and lighting with high-efficiency ones.

Energy renovation of buildings

Existing measures to encourage the renovation of buildings in the Republic of Croatia, primarily include the implementation of national energy renovation programs and include all purposes of buildings, private, public and commercial users, as well as buildings of the poorest performance in assisted areas and areas of special state concern.

The strategic goal set in the Long-Term Strategy for the Reconstruction of the National Building Fund by 2050 (Official Gazette, No. 140/20) is to transform the existing building stock into a highly efficient fund by 2050. This means increasing the renewal rate from the current 0.7% per year (1,350,000 m²) to 3% in 2030, then to 3.5% from 2031 to 2040 and to 4% from 2041 to 2050. Expressed in the area of renovated buildings, the target is 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. Additional indicators of progress that will be monitored through the register of issued energy certificates of buildings, are the increase in the quality of the building envelope, the number and area of nZEB buildings and reconstructed buildings to the level of nZEB. It also monitors the reduction of energy consumption in public sector buildings and residential buildings, the average heat required for heating/cooling in a renovated public sector building, the contribution to reducing energy consumption and the contribution to economic development by increasing the number of employees during renovation.

In the next period, in-depth renovation will be especially encouraged, which includes energy efficiency measures on the building envelope and technical systems and results in a reduction in energy consumption for heating (QH, nd) and primary energy (Eprim) on an annual basis [kWh/(m2·a)] of at least 50% in relation to energy consumption before renovation and comprehensive renovation of buildings, which includes optimal measures to improve the existing condition of the building and in addition to energy renovation measures, includes measures such as increasing fire safety, measures to ensure healthy indoor climates, measures to improve the mechanical resistance and stability of the building - especially to reduce the risks associated with earthquakes.

Technical possibilities for energy renovation, primarily rely on the reduction of energy demands through the renovation of the building envelope in accordance with applicable regulations. The requirement for nZEB includes the improvement of technical systems in buildings and the minimum share of renewable energy sources in accordance with the Technical Regulation on the rational use of energy and thermal protection in buildings. Nearly zero energy buildings meet the requirements for the use of RES, if at least 30% of the annual energy delivered for the operation of technical systems in the building is paid from RES.

Modernization of thermotechnical systems

The renewal of the building envelope is complemented by the centralization and modernization of heating, cooling and ventilation systems and the preparation of DHW with the use of renewable energy sources. It is necessary to insist on a reduction of the required energy for heating and cooling by at least 50%, therefore it is necessary to encourage the implementation of the analysis of the use of highly efficient alternative systems and apply these systems whenever feasible. Alternative systems include: heat pumps, biomass hot water boilers (pellets), solar hot water systems, photovoltaic systems, cogeneration and district heating. DHSs enable centralized use of RES in the immediate vicinity of the building, which increases the share of RES in locations where the technical possibilities of installing RES systems on buildings are limited.

Encouraging the further development of DHS based on high-efficiency cogeneration and the use of RES is at the heart of EU energy efficiency policy.

Without the introduction of small and micro cogeneration, heat pumps or connection to high-efficiency heating systems during building renovation, targeted emission reductions in buildings will not be achieved, as well as a zero energy consumption standard for new buildings.

It is necessary to connect investments in large district heating infrastructure programs with energy efficiency in buildings, in order to achieve the desired goals.

6.4.3. Guidelines for Low-Carbon development

<u>By 2030</u>

- It is necessary to continue the implementation of energy renovation of buildings with the ultimate goal of transforming the existing fund into an energy efficient and decarbonized building fund.

- Due to the requirements to increase efficiency and reduce pollutant emissions, it is recommended to encourage DHS on biomass where possible, and only then individual systems that use modern biomass, such as pellets or briquettes. It is necessary to make an additional analysis of the needs for incentives in the use of RES for heating and cooling in order to determine the necessity of incentives for such systems to achieve the goals by 2030.
- It is necessary to make an analysis and propose a solution to replace the use of solid biomass in households, in cities that are excessively polluted with fine particles and implement action plans to improve air quality.
- It is proposed to introduce integrated urban renewal planning at the level of city districts, in order to facilitate the development of DHS and the modernization of heating systems.
- The tourism sector needs to be encouraged to implement Low-Carbon development policies more quickly.
- Renovate the existing stock of buildings in depth, and build new buildings in the standard of nearly zero energy buildings (nZEB).
- The needs for cooling energy are expected to increase, and it is recommended that, in line with European trends, options be considered to encourage refrigeration storage systems in buildings, district cooling systems in cities that have opportunities, thus optimizing the operation and heat utilization in the summer months in cogeneration plants, cooling systems in buildings and other innovative possibilities.
- In the reconstruction of buildings, in all areas of the Republic of Croatia affected by devastating earthquakes, it is recommended to carry out a comprehensive renovation.

By 2050

- Reduction of emissions in these sectors will depend on the continuation of measures, and the dynamics of building renovation after 2030 in accordance with the Long-term strategy of renovation of the national building fund until 2050 and the renovation rate of 3% in 2030 will continue to increase to 4% in 2050. In this period, all new construction will be nearly zero energy standard buildings, which includes the use of renewable energy sources.
- Regarding the use of RES, it is planned to continue the increase in the use of solar thermal systems for hot water preparation, increase the satisfaction of heating demands using heat pumps and further development of DHS using RES, while reducing the use of traditional firewood.
- The final cost-effectiveness and application of the solution will depend on the technological and commercial development of technologies by 2050.
- Ensure a reduction in greenhouse gas emissions in buildings by 80% and transform the stock of buildings into buildings of nearly zero energy or with a high level of energy efficiency.

6.5. INDUSTRY

6.5.1. Greenhouse gas emissions

Greenhouse gas emissions from the manufacturing industry account for about 21.1% of the total emissions of the Republic of Croatia (2018), of which 48.3% relate to emissions due to fuel combustion, and 51.7% to process emissions. This sector does not include emissions from the electricity and heat production delivered to the manufacturing industry, as they are calculated in other sectors. The largest sources of greenhouse gas emissions, along with large energy sources, are included in the ETS system. These are: production of cement, production of lime and other mineral products, production of ammonia and nitric acid, and production of iron and steel.

Emissions from the use of substitutes for ozone-depleting substances (HFCs) in 2018 were at the level of 2.1% of the total greenhouse gas emissions of the Republic of Croatia. The share of emissions from the consumption of sulphur hexafluoride (SF_6) is 0.3% of the total greenhouse gas emissions of the Republic of Croatia.

In the manufacturing sector, in scenarios NU1 and NU2, compared to 1990, emission reductions are achieved by 54.1 to 57.5% in 2030 and by 64.4 to 83.0% in 2050.

6.5.2. Policies and measures for Low-Carbon development

ETS impact

Since most industrial plants are included in the ETS, there is not much possibility of direct state influence on the reduction of ETS emissions. In the period until 2030, ETS participants will continue to receive part of the allowances free of charge. The 2030 Climate and Energy Policy Framework extends the free allocation further based on a comparison with benchmarks for products, heat, district heating and fuel.

For the industry, the key will be the price of emission allowances on the ETS market, i.e. signals related to long-term price predictability. The question is when and how much the industry will react to the ETS policy, on which the greenhouse gas emissions will depend. The possible effect of industry on price increases will depend on the share of the price of allowances in variable costs, the possibilities of adjustment and the extent to which the price of allowances can be passed on to customers. In addition, the Republic of Croatia has a risk of "carbon leakage" and industry competition from neighbouring non-EU countries and under strong commitments to reduce greenhouse gas emissions. In investing, the allowances price signal will play a significant but not crucial role. Decision-making will also be influenced by the general context of changes in the sector as a whole (energy efficiency, labour market, standards, etc.).

Support for industry from public funds is possible under state aid rules. The industry needs to provide other lines of financing through development banks, guarantee models and international development loans. Reducing greenhouse gas emissions is only part of the overall modernization of industrial processes and is often inseparable from the total investment.

Measures

Low-carbon scenarios include the implementation of cost-effective measures to reduce greenhouse gas emissions from energy consumption by industry and process emissions in cement production and reduce fluorinated greenhouse gas emissions.

Scenario NU2 includes the **implementation of CO_2 capture and storage measures** in cement production plants in the years after 2040 and more intensive implementation of process measures in cement production.

Industrial plants have large areas at their disposal, which is an opportunity to build solar thermal systems and energy tanks. Industry can also participate in the electricity and heat production for other consumers by using RES.

In industry, it is necessary to promote the concept of circular economy, recycling and recovery of waste material in its own process and from other entities.

In the development of scenarios for fluorinated greenhouse gases, assumptions are made to limit and reduce their use, in accordance with the provisions of Regulation (EU) no. Regulation (EC) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 (OJ L 150, 20.5.2014) (hereinafter: Regulation (EU) No 517/2014), and Directive 2006/40/EC of the European Parliament and of the Council of 17 May 2006 on emissions from the air conditioning system in motor vehicles and amending Council Directive 70/156/EEC (OJ L 161, 14.6.2006) (hereinafter: Directive 2006/40/EC).

Scenarios NU1 and NU2 include a more intensive reduction of fluorinated greenhouse gases available on the market after 2030, compared to the NUR scenario, according to an expert assessment based on the continuation of the trend of decreasing fluorinated greenhouse gases. Scenarios NU1 and NU2

include assumptions about the number of vehicles, which is related to the reduction of fluorinated greenhouse gas emissions from mobile air conditioning systems.

6.5.3. Guidelines for Low-Carbon development

By 2030

- The ETS remains the main instrument of emission reduction policy of industrial sector. In all investment decisions, it is necessary to take into account the fact that the prices of emission allowances in the period from 2021 to 2030 are likely to be about 35 EUR/t CO_2.
- During this period, the industry in ETS needs to take concrete steps to move closer to the benchmarks of best available techniques. This includes increasing energy efficiency, modernizing the process, switching to Low-Carbon fuels, using hydrogen as an energy source, increasing the use of climate-neutral electricity.
- Energy consumption monitoring systems should also have a carbon footprint calculation.
- A study of the impact of the NU2 scenario on the manufacturing sector needs to be made.
- It is necessary to encourage studies of innovative solutions and pilot projects that lead to the reduction of greenhouse gas emissions of key industrial entities.
- Particularly encourage solutions that contribute to stimulating the circular economy.
- It is necessary to limit the quantities of fluorocarbons available on the market until 2030, in accordance with the provisions of national and EU legislation.
- It is necessary to limit the possibilities of retrofitting air conditioning equipment, designed to contain fluorinated greenhouse gases with a global warming potential above 150 in motor vehicles, and to prohibit the filling of air conditioning equipment with these gases.

By 2050

- In all investment decisions it is necessary to take into account the fact that the prices of emission allowances, in the period from 2030 to 2050, will reach the level of 90 EUR/t CO_2.
- Increasing energy efficiency, use of RES, modernization of production processes, application of recycled materials, inclusion in the chains of the circular economy and bioeconomy, use of natural materials and raw materials, use of climate-neutral electricity and energy forms (hydrogen, synthetic fuels), biofuels where it is not possible to use climate-neutral electricity or energy forms.
- To achieve the objectives of the NU2 scenario, the cement and processing industry and the fertilizer industry need to analyze the feasibility of the CCS system.
- Encourage limiting and reducing the use of fluorinated greenhouse gases.
- Services and products should have reported carbon footprints monitored throughout the overall life cycle.

6.6. AGRICULTURE

6.6.1. Greenhouse gas emissions

This chapter discusses N_2O and CH_4 emissions. Binding of carbon to agricultural biomass and soil is processed in the LULUCF sector. CO_2 emissions from fuel consumption in agriculture and fisheries are treated in the general consumption sector.

In 2018, agriculture accounted for approximately 11.4% of total national greenhouse gas emissions. The application of mineral fertilizers is the main source of nitrous oxide emissions (29% of sector N_2O emissions and 15% of total sector emissions), with methane emissions from livestock farming (46% of total sector emissions).

In this sector, compared to 1990, in Low-Carbon NU1 and NU2 scenarios, emission reductions are achieved by 44.5 to 46.3% in 2030, and by 50.9 to 55.8% in 2050, respectively.

6.6.2. Policies and measures for Low-Carbon development

An attempt to drastically reduce emissions in agriculture would have a direct impact on food production, changes in crop yields, the way agricultural land is used, and changes in productivity and the composition of livestock. The implementation of measures in the agricultural sector, therefore, has a strong economic and sociological dimension.

Agriculture is a sector that is particularly vulnerable to climate change. The fundamental challenge is how to reduce greenhouse gas emissions and maintain food production. Climate change is just one of the pressures on agriculture. In the global context of increasing competition, food production must be viewed through a common context, agriculture, energy and food security.

The vision of Low-Carbon development in the agricultural sector implies full application of good agricultural practice, which should be applied by educated farmers, in restored villages, on large farms, with high yields of diverse crops resistant to climate change and weather risks. The economies will be economically viable and competitive, with cultivation oriented towards eco-production and a green market, with the use of agri-environmental and agroforestry systems. Rural areas and economies will be nearly energy neutral and resource efficient. Biomass for fuels will be produced without jeopardizing food production, while proactively contributing to reduced greenhouse gas emissions with negligible environmental impacts. All measures to be taken will be based on cost-effectiveness, taking into account socio-economic and natural characteristics.

The positive impact of the implementation of measures on the total greenhouse gas emissions in the agricultural sector is manifested through a direct reduction in emissions of methane and nitrogen compounds. The measures included in the formation of the NU1 scenario of agriculture in relation to the NUR scenario are:

- changes in the cattle and pigs diet and the composition of animal feed;
- anaerobic digestion (silage and renewable ligno-cellulose raw materials, organic by-products of the food industry and slaughterhouses, biodegradable fractions of municipal solid waste and microbial biomass) and biogas production for electricity and heat production and fuel for internal combustion engines;
- improve facilities or dwellings as well as the fertilizer management system;
- improve fertilizer application;
- construction of hydromelioration projects;
- encourage the development of "precision agriculture" based on developed GIS and GPS technologies;
- introduction of new cultivars, varieties and species.

At EU level, the Common Agricultural Policy is implemented, which takes into account the specifics of the Member States. Sensitivity to the implementation of measures has been identified at EU level as a key challenge. Therefore, in the Climate and Energy Policy Framework until 2030, a mechanism has been proposed which allows Member States, if necessary, to use billing for sectors outside the ETS, i.e. the use of sinks caused by changes in carbon stocks by planting new forests, changes in carbon stocks on agricultural land and sinks due to changes in carbon stocks on managed pastures. This flexibility is determined based on the share of agriculture in the total greenhouse gas emissions of the sector outside the ETS. In order to enable it to use this flexibility, it is necessary for the Republic of Croatia to establish a comprehensive system for monitoring changes in carbon stocks in agricultural soil and pastures, i.e. in all categories of land use, as defined by LULUCF.

To assess the potential reduction of total emissions expressed through an increase in organic carbon in the soil (LULUCF sector), by implementing an additional set of measures, it is necessary to conduct national surveys to define the actual potential for carbon increase in agricultural soils in the Republic of Croatia, particularly a relation of the reduced tillage system with regard to fertilization recommendations, and continue to explore the potential for application depending on the type of soil. Measures that have the potential to increase carbon sequestration:

- improvement and change of tillage system (reduced tillage)
- expansion of crop rotation with a higher share of legumes
- intensification of crop rotation using intermediate crops
- improving the application of organic fertilizers
- green manure
- agroforestry.

It should be mentioned that an additional significant (direct and indirect) reduction of greenhouse gas emissions could be achieved with changes in the human dietary habits, i.e. measures that would encourage higher consumption of food of plant origin. Such measures imply significant changes in the structure of agricultural production, especially livestock. Reducing food residues and losses should be one of the priority measures.

It is necessary to encourage the development of projects for biogas production and projects for the biomass collection, created after the pruning of permanent crops and the harvest of field species and the production of agropellets. Avoided emissions from the use of biomass are calculated in the energy sector. The same concerns the planting fast-growing crops for biomass production.

Biofuel production must not be to the detriment of food production, so biofuels that are certified with regard to sustainability criteria will be acceptable.

<u>Research, development and promotion of local and regional connections between agricultural producers and the tourism sector</u>

In addition to technical measures to reduce greenhouse gas emissions or introduce alternative tillage methods and livestock farming and keeping processes, it is certainly necessary to consider the possibility of exploiting the great synergy potential of agricultural production. Many processing industries as well as the tertiary service sector are complementary or directly dependent on agricultural production. Since the Republic of Croatia has great development strength in preserved natural (water, soil) resources, preserved landscape values and the fact that it is a strong tourist recipient (with great potential for rural and ecological tourism), education and encouraging local connection of the entire food chain "from the field to the table "- i.e. connecting the local tourist offer, processors and local producers, one can certainly expect a reduction in greenhouse gas emissions - both directly by using organic agriculture or farming technology with lower nitrogen losses, and indirectly by reducing emissions from transport, storage and processing far from places of production of agricultural products.

6.6.3. Guidelines for Low-Carbon development

By 2030

- Improvements in livestock farming and feeding regime are expected (feed processing with the aim of increasing digestibility, improving the quality of forage and improving the grazing system, use of feed additives), with the construction of biogas plants (introduction of biogas plants on large and medium farms - expected 25% of the total number of pigs, cattle and poultry.). In this period, the further trend of the number of head of livestock will be clearer, from which the priority sources of emissions will be more clearly defined.
- Strengthen the system of collecting pruned biomass from permanent crops and field biomass, taking into account the need to leave and introduce field biomass into the soil, in order to increase the content of organic matter in the soil, i.e. to maintain soil fertility.
- Prepare a study of the possibility of planting fast-growing species and encourage several pilot projects.
- Measures to reduce food waste should be encouraged and implemented as a matter of priority.
- Models need to be developed and proposed to encourage innovative integrated projects, agriculture, energy and food production.
- It is necessary to analyze the possibilities for the use of treated wastewater for irrigation of agricultural land.
- Implementation of measures from the Rural Development Program of the Republic of Croatia for the period 2014-2020, the new programming period and the adoption of the "Agriculture Strategy for the period until 2030" will define the goals and guidelines of agricultural policy, while program and planning documents in the field of Fisheries and Aquaculture for the period after 2020, further goals and priorities for the development of the fisheries and aquaculture sector will be defined.
- Construction of drainage system, irrigation system and protection system against natural disasters on at least 40% of agricultural land, which will affect N_2O emissions.
- Increasing the share of co-fertilizers to 10% in the total consumption of mineral fertilizers.
- Conduct national surveys to define the real potential for increasing carbon sinks in agricultural soils, through sequestration of organic carbon in the soil, especially in combinations of minimum tillage systems and cover crops in cereals, improving the use of organic fertilizers and agroforestry.
- National surveys of new varieties that are more resistant to drought or disease, i.e. have a lower total carbon footprint, and incentives for the transition and adaptation of the entire production chain to the production of new agricultural species. This includes targeted species for biomass production for power plants.
- Regulate the application of fertilizers based on soil analyses that are measurable, and develop the so-called fertilization calculators that will, depending on the soil supply, define the required quantities, methods of application and types of fertilizers.
- Encourage projects that improve the protection systems of agricultural land as a non-renewable natural resource of the Republic of Croatia.
- It is necessary to encourage projects for the development of information technologies applied in precision agriculture and research related to their application in practice (use of drones, smart mechanization, automatic meteorological stations, etc.).

By 2050

- Optimizing the application of organic and mineral fertilizers. It is planned to increase the share of slow-acting fertilizers by 15% in the total share of mineral fertilizers as well as to increase the share of new varieties.
- Continuation of the introduction of biogas plants on farms, whereby 30% of the residues of primary biomass of pigs, cattle and poultry should be processed on digesters.
- It is planned to build hydromelioration interventions and protection systems against natural disasters on as many agricultural areas as possible.

- It is expected that increasing productivity and structural changes in agriculture will enable the implementation of new measures that are not yet in force today.
- Linking GHG mitigation measures to climate change adaptation measures.
- Measures of common agricultural practice should be valorised through a contribution to reducing emissions and increasing emission sinks within the LULUCF sector.

6.7. WASTE

6.7.1. Greenhouse gas emissions

The waste sector participates in the total greenhouse gas emissions of the Republic of Croatia with 8.6% in 2018, of which 99.6% comes from key emission sources: solid waste disposal and wastewater management. Of this, 86.9% of emissions relate to solid waste disposal.

In the waste sector, emissions in 2030 are still higher than in 1990, given that emissions will increase until 2018. Compared to 1990, this sector recorded an increase in emissions by 35% in 2030. Emission reductions are expected only in 2040 (by 7.6%). In 2050, the reduction will be 29.4% compared to the 1990 emission level.

6.7.2. Policies and measures for Low-Carbon development

Impact of sustainable waste management

By preventing generation, separate collection, recycling and recovery of waste, the amount of solid waste for disposal will be reduced to a minimum. All landfills will be remediated, waste management centres will use advanced technologies which, in addition to obtaining raw materials for material recovery, waste is chemically recycled to obtain various chemical compounds that can be used in industrial production (ethylene, ammonia, etc.), as well as various fuels (hydrogen, synthetic gas, liquid fuels). The new landfills will be arranged in such a way that their impact on the environment is negligible. Establishing a waste management system in accordance with the principles of the circular economy will contribute to resource efficiency with less negative impact on people and the environment.

The EU Circular Economy Action Plan aims to improve the conditions for more sustainable growth, use resources more efficiently and establish consistency with other policy areas. The action plan covers a number of topics and measures, from product design through consumption, to waste management and recognition of the greater value of resources. The plan is to change the legislative framework for the development of the circular economy, set long-term goals for waste management and implement further specific measures. In addition, the Action Plan should support businesses, society and Member States, both at regional and local level, during implementation. The Action Plan explicitly emphasizes the global dimension of this issue and refers to the set goals of the UN Program for 2030 for Sustainable Development.

Sustainable waste management means:

- reduction (avoidance) of waste generation and greenhouse gas emissions
- established waste management system
- remediated landfills
- complete waste recovery using all modern and available technologies.

Projections of greenhouse gas emissions from the waste sector are based on the implementation of measures prescribed by sectoral legislation, complied with EU legislation.

The preparation of projections from the disposal and biological treatment of solid waste (composting) includes assumptions based on the existing legal framework of the Republic of Croatia and the adopted EU legal framework on the waste sector for the period until 2035. A five-year delay for the Republic of Croatia is included in the projections. For the period after 2040, the assumptions for the implementation

of measures based on expert assessment were used, in accordance with the assumptions defined by the adopted planning documents.

In the projections of emissions from waste incineration, it is assumed that the incineration of hospital waste is no longer carried out without energy recovery.

Emission projections from wastewater management for the period up to 2050 are calculated based on emissions from the last historical year (2018), using projections of the annual GDP growth rate and population.

Measures

Low-carbon scenarios include application of measures to reduce greenhouse gas emissions from solid waste disposal.

The following measures are included in the NUR scenario:

- preventing generation and reduction of solid waste
- increasing the amount of separately collected and recycled solid waste
- ensuring the system of treatment and use of landfill gas
- reducing the amount of disposed biodegradable waste
- use of biogas for production of biomethane, electricity and heat.

The decrease in the amount of disposed biodegradable waste results in an increase in the amount of biodegradable waste referred to biological treatment processes, such as composting and anaerobic digestion in biogas plants, which causes an increase in CH_4 emissions during the observed period from composting activities in the waste sector. The overall effect of reducing the amount of disposed biodegradable waste is positive, i.e. there is a reduction in CH_4 emissions due to reducing the amount of disposed biodegradable waste in landfills, which is prescribed by sectoral legislation.

The potentials for reducing CO_2 emissions that can be realized by implementing the measures included in the NUR scenario are balanced in the Energy sector.

The NU1 and NU2 scenarios are equal to the NUR scenario, as no additional measures to reduce emissions were identified. A comparative analysis of a group of countries with similar national characteristics found that national legislation, which is in line with EU legislation, prescribes measures that all Member States must implement by a certain deadline and considers them within the measures scenario (corresponding to the NUR scenario).

According to the goals from the EU Action Plan for the Circular Economy and the integrated approach in the new package of measures for the circular economy and the revised EU Directives, intensive implementation of measures in the period until 2035 is planned, as well as raising the level of goals related to resource efficiency, recycling, reuse and waste management.

6.7.3. Guidelines for Low-Carbon development

By 2030

- Saving raw materials by applying waste prevention and recycling measures.
- Establishing a system of separate waste collection, in accordance with objectives of national and EU legislation.
- Full implementation of remediation and closure of existing landfills.
- Establishing a comprehensive waste management system according to the order of priority, which is implemented in accordance with objectives of EU directives - establishing waste management centres.

- Encouraging production from renewable energy sources - landfill gas power plants and gas from wastewater treatment plants, biogas and biomass power plants.
- Efficient waste recovery - the backbone of the system consists of recycling centres with sorting plants, all separately collected waste needs to be recovered - raw material management - circular economy.
- Transfer of knowledge and experience of EU countries in applying best available techniques for waste treatment.
- Developing awareness of the need for waste management - circular economy, encouraging cross-sectoral cooperation (food industry, agriculture, forestry…).
- Development of new waste treatment technologies - investment in research and development.
- Providing subsidies for investment projects - use of funds from EU structural and investment funds.
- Creating a positive environment for attracting investment.
- Implementation of the program of development of circular management of space and buildings.
- Development of new waste treatment technologies - investment in research and development.
- Providing subsidies for investment projects - use of funds from EU structural and investment funds.
- Creating a positive environment for attracting investment.
- Implementing the program of development of circular management of space and buildings

By 2050

- Establishing a waste management system in accordance with principles of the circular economy.
- Developing new waste treatment technologies - investment in research and development.
- Implementing programs for investment in cost-effective waste treatment measures, which achieve a greater reduction in greenhouse gas emissions.
- Full functioning of the complete system of circular management of space and buildings.

6.8. Land Use, Land Use Change and Forestry (LULUCF)

6.8.1. Greenhouse gas emissions and sinks

The Land Use, Land Use Change and Forestry (LULUCF) sector is the only sector in which sinks (removal) of carbon dioxide from the atmosphere occur, as well as greenhouse gas emissions. The LULUCF sector is regulated internationally by the UNFCCC, the Kyoto Protocol, the Paris Agreement and EU policies. As part of international negotiations to reduce greenhouse gas emissions, the LULUCF sector has always been treated separately due to the fact that only in it do sinks appear as a result of anthropogenic activity and natural processes.

At the sector level, the LULUCF sector in the Republic of Croatia is a sink sector. The LULUCF categories of *Forest Land* and *Grasslands* are categories in which, when sinks and emissions are added together, these categories ultimately result in a sink (removal) of greenhouse gas emissions. In the categories of *Crops/Plantations, Settlements* and *Wetlands,* the final calculation for each category is emissions. In the *Other land* category, no emission/sink calculation is performed. In the period from 1990 to 2018, the sinks were (in absolute value) the lowest in 2017 (-4728.71 kt CO_2), and the highest in 1995 (-8954.6 kt CO_2).

In the LULUCF sector, a trend of sink reduction has been recorded. The biggest reason for this is the lack of implementation of prescribed forest management practices on all forest areas, during the Croatian War of Independence and during the post-war period. The war and the consequences of the war caused a disruption of the structure of forest stands and led to a decrease in forests growth, due to the lack of timely implementation of the prescribed cultivation interventions (absence of logging). The works envisaged by the Forest Management Plan of the Republic of Croatia for the period 2016-2025, should lead to the establishment of an appropriate structure of stands, for which it is necessary to carry out all

works that were not carried out in time in stands that were in war-affected areas. as well as in areas affected by post-war events (e.g. mined and mine suspected forest areas).

6.8.2. Policies and measures for Low-Carbon development

In order to achieve the objective of reducing greenhouse gas emissions by 20% by 2020 compared to 1990 emissions, the European Union did not take into account sinks/emissions from the LULUCF sector.

Decision no. 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use land-use change and forestry and on information concerning actions relating to those activities (hereinafter: Decision No. 529/2013/EU), set rules for the calculation of emissions and sinks from the LULUCF sector as a first step to involve these units in achieving the long-term EU objectives of reducing greenhouse gas emissions.

Recognizing the limited potential of the LULUCF sector to contribute to climate change mitigation, the Regulation also elaborates a flexibility mechanism (sink trading system) to facilitate Member States' compliance with their obligation to maintain total sinks greater than total emissions for given land categories by 2030.

Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (hereinafter: Regulation 2018/841/EU), the basic principle of the so-called "no debit rule" has been kept, which aims to ensure that emissions in the LULUCF sector do not increase.

There are two methods of calculating emission units/sink units in the sector:

- Gross-net calculation when the total amount of emissions and sinks in a certain period (2021-2025, 2026-2030) is taken into account and not compared with another, default value. This type of calculation is applied in the case of emissions/sinks of forested and cleared forest land.
- Net-net calculation when emissions/sinks in a defined period are compared with some determined value (e.g. from the base year). This type of calculation is applied in the case of emissions/sinks on managed forest land and the Forests Reference Level (FRL) is applied, on managed pastures and managed agricultural land. Regulation 2018/841/EU in determining the forests reference level, takes into account the fact that the Republic of Croatia was not so long ago under military occupation and that the war had a negative impact on forest management in the Republic of Croatia. For the first period prescribed by the Regulation (from 2021 to 2025), the currently proposed value of FRL for the Republic of Croatia is -4,368 Mt CO_2e. Removals from the wood products category are also included here, while the value without them is -3,906 Mt CO_2e.

According to national projections of greenhouse gas emissions and removals, one possibility is that the sinks in the LULUCF sector will continue to be reduced, so that the possible removal of carbon dioxide in 2030 could be less than the current one. This refers to the real sink, which is not equal to the calculation sink, according to Regulation 2018/841 EU. Measures under this Strategy should help to maintain the calculation sink units until 2030 and that the LULUCF sector does not become a source of emissions.

Taking into account the obligations in the LULUCF sector defined according to EU regulations, continuous work on improving the calculation of emissions/sinks in this sector, and conducting analysis of all LULUCF land categories to identify their potential to reduce emissions and increase sinks for each of the land categories is a necessity in order for flexibility mechanisms to be used in the best possible way for the Republic of Croatia (possibility of transfer (sale) to other Member States of surplus sink units or transfer of surplus units for the period 2026-2030).

The LULUCF sector covers the total land area of the state, and competencies over certain land categories in this sector are distributed among several different institutions of the Republic of Croatia. Consequently, in order to effectively plan measures to ensure emission reductions, sink increases and fulfilment of obligations defined by Regulation 2018/841 in the period until 2030, i.e. 2050, it is necessary to develop strategic guidelines for land management in the Republic of Croatia.

Defining measures to increase sinks and reduce emissions when improving land management in the Republic of Croatia should be complied with different requirements (food production, biomass energy, biodiversity conservation, wood products), with this issue becoming particularly important in increasing the ambition of a Low-Carbon Strategy, according to zero net emission in the following iterations of its production.

It is noted that planning measures to reduce emissions and increase sinks by taking into account only emissions/sinks in one repository (e.g. phytonutrients (biomass)) may have the wrong effect and result in increased emissions. For example, the change of grassland into forest land (afforestation) results in emissions in the case of soil repository after the change, since the carbon stock in this soil category is higher than the carbon stock in forest land.

The introduction of new management practices in certain LULUCF land categories may have a negative impact on the fulfillment of obligations under Regulation 2018/841. In the case of removal of wood residue after felling and production in the forest for energy purposes, it was found that this practice has a negative impact on the carbon cycle in repository in *forest land* and in the long run leads to reduced carbon stocks in soil, hardwood and dead wood repository.

Detailed knowledge of emissions/sinks that occur in each repository in each land category is a prerequisite for good planning of measures to reduce emissions and increase sinks that should be identified and form an integral part of the measures of the Rural Development Program of the Republic of Croatia.

It is necessary to improve land management (cover, land use, management methods on each land category), which would take emissions/sinks in each LULUCF land category as a starting point. In the Republic of Croatia, it is still necessary to implement land management practices that have so far resulted in sinks.

For forest land, it is a continuation of the tradition of long-time (sustainable) forests and forest lands management in accordance with the professional rules and the requirements of domestic and international policies. Available, non-overgrown productive forest land needs to be used to raise new forests. Areas overgrown with low-growing forests need to be managed in such a way as to increase carbon stocks. Management of wood residues after felling and production in forest stands should be regulated by conducting scientific research on the impact of removal of wood residues on the carbon cycle in forests. Forest resources need to continue to be managed in such a way as to maintain and improve their general useful functions (OKFŠ), protect biological diversity and raise the resilience of forests to climate change. It is necessary to encourage the use of wood products in traditional and new products, and to take awareness of the importance of wood products as carbon repository, and their importance in terms of additional avoided emissions when the use of these products avoids emissions from the production of e.g. plastic products.

In competitive business, there will be more and more management systems, integrated business and development projects that take into account aspects of climate change in terms of increasing sinks, reducing emissions and increasing resilience to climate change. Cross-sectoral action, compliance and achieving synergies are important, with a high level of information on forest condition, inventory, vulnerability and trend projections.

It is necessary to regulate the export of wood raw materials, semi-processed wood in order to encourage the finalization of the domestic wood industry and energy wood, bearing in mind that this adversely affects the balance of renewable energy sources.

In the period until 2030 and 2050, it is necessary to provide funding for technical projects and scientific research related to LULUCF land categories and emissions/sinks in this sector, and use the research results to plan measures and future climate change policy in the Republic of Croatia in the period by 2030 and 2050.

Guidelines for the future development of the LULUCF sector defined by the low-carbon development strategy should ensure the achievement of a long-term goal for this sector - total sinks should be higher than total emissions from the calculated land categories.

6.8.3. Guidelines for Low-Carbon development

By 2030

- Continuously work on improving the calculation of emissions/sinks in the LULUCF sector through the implementation of various projects which results enable the application of a higher level of IPCC methodology (Tier 2, Tier 3) in the calculation of emissions/sinks.
- In cooperation with the competent authorities, develop guidelines for land management with the aim of increasing the sink in the Republic of Croatia. Prerequisites for their development are:
    - develop a unique land information system in the Republic of Croatia or determine the areas of individual LULUCF land categories using spatially accurate data, for each land category and for each type of land change from one land category to another
    - conduct an analysis of all LULUCF land categories depending on cover, land use and management practices used on each land and associated emissions/sinks to consider the potential of each repository, within each LULUCF land category to reduce emissions and increase greenhouse gas sinks
    - develop detailed projections of the future emissions/sinks in the LULUCF sector after conducting the above analysis.
- After conducting the above analysis, define activities to reduce emissions/increase sinks for each of the land categories and associated repositories, and define deadlines for the implementation of defined activities. This should be an integral part of the land management system of the Republic of Croatia.
- Implement selected activities defined in the measure of improving the land management system of the Republic of Croatia due to the reduction/maintenance of emissions and the increase/maintenance of greenhouse gas sinks in the LULUCF sector.
- Within the framework of sustainable forest management, the introduction of new forest management practices should be conditioned by the implementation of scientific papers proving the positive effect of new management practices on the carbon cycle in forest repository, and consequently on emissions and sinks in the Forest Land category.
- At the national level, improve and harmonize regulations in the forestry, agriculture and environmental protection sectors in order to achieve the goals defined by EU policy in the field of climate change.
- Carry out an analysis of the effectiveness of implemented measures and activities from the currently valid Rural Development Program of the Republic of Croatia for the period 2014-2020, as well as the program for the new period (2021-2027) for the agricultural and forestry sector and measures defined in the study to meet obligations according to Article 10 of Decision No. 529/2013/EU, to reduce/maintain emissions and increase/maintain greenhouse gas sinks in order to develop new guidelines and define measures in the forestry and agricultural sector for financing in the Rural Development Program of the Republic of Croatia in the period after 2027.

- Conduct scientific research to improve the management of all LULUCF land categories in order to reduce emissions and increase sinks.
- Carry out afforestation in accordance with forest management plans.
- Evaluate the effect of afforestation of non-overgrown, productive forest land on the fulfilment of the Republic of Croatia obligations related to the use of renewable energy sources.
- Improve forest fire protection planning.
- Promote ways of managing forests, pastures and agricultural land areas that are beneficial for climate and environment.

By 2050

- Analysis and evaluation of the effects of implemented measures in different periods for reduction/maintenance of greenhouse gas emissions and increase/maintenance of carbon stocks in carbon repositories.
- Development of guidelines for further development in the LULUCF sector based on knowledge and experience gained from the land management system and defined activities and measures to reduce emissions and increase sinks.
- Development of guidelines for the improvement of forest management methods and development of a plan for the implementation of forest management activities in a way that increases forest sinks.
- Securing funding for technical projects and scientific research related to LULUCF land categories and emissions/sinks in this sector.

7. FINANCING

7.1. ASSESSMENT OF REQUIRED INVESTMENTS

In the long run, investments in low-carbon development need to be economically sustainable. Public sources of funding will not be sufficient and instruments need to be found to mobilize private funds to invest in projects that contribute to low-carbon development and economic growth.

It is estimated that the transition to low-carbon development will require investments of 38.65 to 65.92 billion HRK in the period from 2021 to 2030, i.e. from 0.92 to 1.6% of GDP. In the period from 2031 to 2050, the cost will be from 107.09 to 167.95 billion HRK (from 0.96 to 1.51% of GDP). These investment amounts represent the difference between investments between transition scenarios (NU1 and NU2) and the reference scenario (NUR).

Figure 7-1 shows an assessment of the required investment in the period from 2021 to 2030 for the transition to a low-carbon economy.

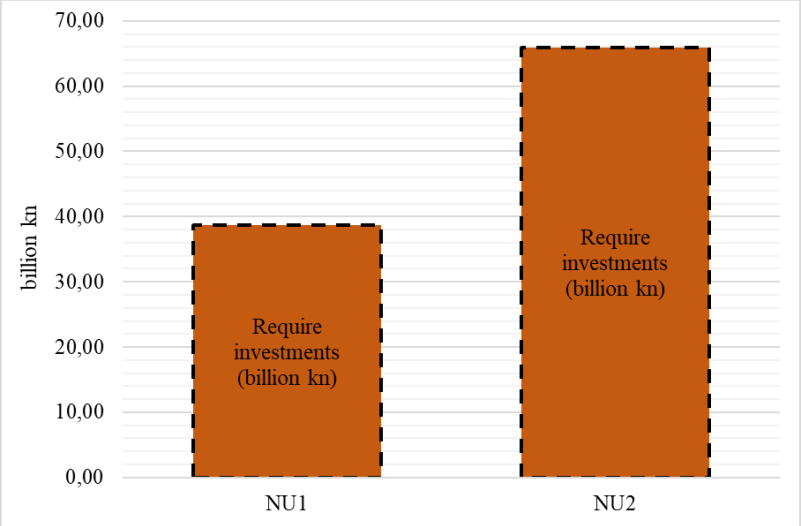

Figure 7-1: Assessment of the required investment in the period from 2021 to 2030 for the transition to a low-carbon economy

Figure 7-2 shows an assessment of the required investment in the period from 2031 to 2050 for the transition to a low-carbon economy.

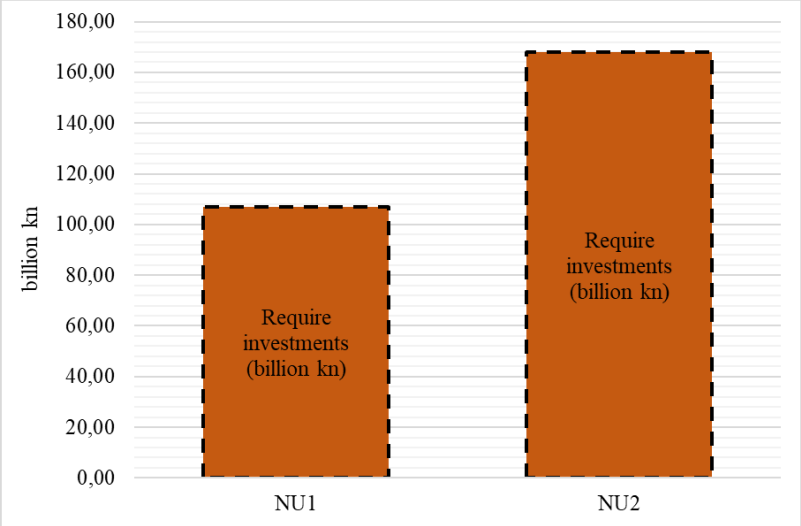

Figure 7-2: Assessment of the required investment in the period from 2031 to 2050 for the transition to a low-carbon economy

7.2. SOURCES OF FINANCING

The framework for financing the measures already exists to a large extent, in terms of possible sources of financing, but it is valid for the period until 2030. After 2030, as the implementation of measures deepens and the cost increases significantly, it will be necessary to provide a wide range of financing sources.

This chapter comprehensively lists the sources of financing available to achieve the goals of the Low-Carbon Strategy.

As in the previous period, it is expected that the main source of financing will continue to be funds from the **European Structural and Investment Funds (ESI)** and **funds raised from auctions of greenhouse gas emission allowances**. In addition, the main sources of financing will be:

- **EU funds and programs**
  - Modernization Fund, from the ETS auction quota
  - Innovation Fund, from the ETS auction quota
  - Connecting Europe Facility
  - European Fund for Strategic Investments (EFSI)
  - Just Transition Fund (JTF)
  - Recovery and Resilience Facility (RRF)
  - European energy programme for recovery (EEPR) and European Energy Efficiency Fund (EEEF)
  - European Social Fund (ESF) and European Social Fund plus (ESF+)
  - European Maritime and Fisheries Fund (EMFF)
  - European Agricultural Fund for Rural Development (EAFRD)
  - Horizon 2020 and Horizon Europe
  - LIFE program
  - Interreg: European Territorial Cooperation (ETC)
  - Other international multilateral financial mechanisms such as e.g. Norwegian Financial Mechanism
- **National financial mechanisms**
  - Republic of Croatia Budget
  - Financing the implementation of measures based on the energy efficiency system according to Directive 2012/27/EU on energy efficiency
  - Fee on CO_2 emissions
  - Fee on electricity generation from renewable energy sources
- **Credits and innovative financing models**
  - Credit lines of commercial banks
  - ESCO financing models
  - Crowdfunding
- **Public-private partnerships (PPP)**

These sources of financing are current in the period until 2020, and additional funds through the eponymous funds and programs will be available in the coming period. Exceptions are the change of the program name from Horizon 2020 (the program in force until 2020) to Horizon Europe (in force from 2021), and the newly established tool Mechanism for Fair Transition of the European Green Plan, which will be active between 2021 and 2027.

An important question is how the Republic of Croatia will program funds from ESI funds from 2021 onwards, how much will be earmarked for climate activities and what will be the distribution between measures to mitigate climate change and measures to adapt to climate change. In the financing period from 2014 to 2020, the Republic of Croatia distributed 20.4% of the total funds to climate activities (EUR 2.18 billion). At the EU level, within the ESI funds, in this period, investments in climate activities amount to 25.1%. If the distribution of ESI funds on mitigation and adaptation at EU level 28 is analyzed, 11.2% is for mitigation, 3.1% for adaptation and 10.5% for mitigation and/or adaptation. In the Republic of Croatia, the distribution until 2020 is as follows: 7.1% for mitigation, 4.7% for adaptation and 8.8% for mitigation and/or adaptation.

Incomes from emission trading at ETS auctions

The collected funds are purposefully used in accordance with the Plan for the use of financial resources obtained from the emission trading through auctions in the Republic of Croatia. The Government of the Republic of Croatia, through the Environmental Protection and Energy Efficiency Fund (EPEEF), uses

auctions to finance measures in the field of transport, energy efficiency, use of renewable energy sources and other measures that contribute to reducing greenhouse gas emissions and adapting to climate change.

EU Structural and Investment Funds

For the period from 2014 to 2020, climate activities are financed through the Competitiveness and Cohesion Operational Program, through the Efficient Human Resources Operational Program, the Maritime Affairs and Fisheries Operational Program and the Rural Development Program. These operational programs draw funds from the European Regional Development Fund (ERDF), the European Agricultural Fund for Rural Development (EAFRD), the European Maritime and Fisheries Fund (EMFF) and the European Cohesion Fund (CF).

Common rules for financing from the Structural and Investment Funds for the period from 2014 to 2020, had rules that through all operational programs at least 20% of funds be used for climate activities - climate change mitigation and adaptation (through operational programs, the Republic of Croatia allocated 20.4%).

For the financial period 2021 to 2027, there are five cohesion policy objectives: 1) Smarter Europe, 2) Green Europe - Low-Carbon by promoting the transition to clean and fair energy, green and blue investments, the circular economy, adaptation to climate change and risk management and prevention, 3) a more connected Europe, 4) a Europe with prominent social components and 5) a Europe closer to its citizens. Funding is provided from seven funds, four of which are potentially available for climate action: the European Regional Development Fund (ERDF), the Cohesion Fund (CF), the European Social Fund plus (ESF+) and the European Maritime and Fisheries Fund (EMFF).

Croatia will have at its disposal more than 23.5 billion euros (over 40% of the annual GDP of Croatia) from the EUR 750 billion aid package for the economic recovery of the Member States and through the amended Multiannual Financial Framework, i.e. the budget of the European Union for the period 2021-2027, which is a strong basis for economic growth and development. More than 30% of these funds will need to be invested in low-carbon development in order to achieve climate neutrality and increase resilience to climate change.

Modernization Fund

From 2021, the Modernization Fund will be established within the ETS system, intended to support investments for the modernization of the energy and industrial sector, as well as to increase energy efficiency. Funds from this Fund are intended for Member States with a GDP per capita of less than 60% compared to the EU average achieved in 2013, and among them is the Republic of Croatia. The allocation of funds from the Modernization Fund will be through tenders announced by the Member State, which also submits project proposals.

The funds of the Modernization Fund envisage the financing of small investment projects, the modernization of energy systems and industry and the improvement of energy efficiency in the Member States. At least 70% of the funds from the Modernization Fund are intended to support investments in electricity generation and use from renewable sources, improving energy efficiency, except for energy efficiency related to energy generation using solid fossil fuels, energy storage and modernization of energy networks, as well as to support a fair transition in carbon-dependent regions in beneficiary Member States, to support the redeployment, retraining and training of workers, education, employment initiatives and business start-ups. The legal basis for the Modernization Fund implementation is given in the Act on Climate Change and Ozone Layer Protection (Official Gazette, No. 127/19).

Innovation Fund (NER 400)

Commission Delegated Regulation 2019/856 stipulates that the Innovation Fund is intended for innovation projects (exclusively "the first for a certain type of technology"), renewable energy sources, carbon capture and storage and energy-intensive industries. This would continue with the application of

the existing project financing mechanism, the so-called NER 300. The allocation of funds from the Innovation Fund will be through open calls for project proposals published by the EC.

Connecting Europe Facility

The Connecting Europe Facility (CEF) is an important EU funding instrument to promote growth, new jobs and competitiveness, through investment in targeted infrastructure at EU level. It supports the development of highly efficient and sustainable trans-European networks in the fields of transport, energy and digital services. As such, it largely provides funding for measures that contribute to low-carbon development. CEF provides grants, but also innovative financial instruments such as guarantees or project bonds. In this way, a greater effect of funds is achieved and investments from the private sector and other public opportunities are initiated.

European Fund for Strategic Investments

The European Fund for Strategic Investments (EFSI) is a key element of the Investment Plan for Europe, which aims to boost long-term economic growth and competitiveness in the EU. The aim of this fund is to contribute to the use of public funds, including funds from the EU budget, to encourage private investment in a wide range of projects in the EU. The projects cover, among others, areas such as infrastructure, research and innovation, education, health, information and communication technology.

European Energy Programme for Recovery (EEPR) and European Energy Efficiency Fund (EEEF)

The European Energy Programme for Recovery allows for the granting of financial assistance in the energy sector, in particular for the deployment of interconnected infrastructures, renewable energy production, carbon capture and the promotion of energy efficiency. The goal of the program is to achieve savings in primary energy consumption and reduce greenhouse gas emissions.

The European Energy Efficiency Fund includes earmarked funding for projects in the areas of energy efficiency, renewable energy sources and clean urban transport. Beneficiaries are local or regional public bodies or private entities acting on their behalf.

European Social Fund (ESF) and European Social Fund Plus (ESF+)

The European Social Fund is one of the European Union's structural funds, the fundamental aim of which is to reduce differences in prosperity and living standards between EU Member States and their regions, and thus to promote economic and social cohesion. The ESF also contributes to other thematic objectives, notably by supporting the transition to an environmentally sustainable, low-CO_2 economy.

During 2018, the EC presented the European Social Fund Plus to support the implementation of the principles of the European Pillar of Social Rights. The ESF+ will merge the European Social Fund, the Youth Employment Initiative, the Fund for European Aid to the Most Deprived, the EU Program for Employment and Social Innovation and the European Health Program.

European Maritime and Fisheries Fund (EMFF)

The European Maritime and Fisheries Fund (ERDF) provides funding to the fishing industry and coastal communities to adapt to changing conditions in the sector and to achieve economic and environmental sustainability. The fund is designed to ensure sustainable fisheries and aquaculture (fish, shellfish and underwater plants). The priority area relates to the promotion of environmentally sustainable, resource efficient, innovative, competitive and knowledge-based fisheries.

European Agricultural Fund for Rural Development (EAFRD)

The resources of the European Agricultural Fund for Rural Development contribute to the achievement of the objectives of the Common Agricultural Policy, in particular in the area of sustainable rural development.

Horizon 2020 and Horizon Europe

Horizon 2020 is the largest EU research and development program, which will continue for the period from 2021 to 2027 under the name Horizon Europe. The new program will build on the achievements of Horizon 2020 with a stronger emphasis on achieving results in the areas of medicine, food and climate change.

LIFE program

The LIFE program is an EU financial instrument to support projects in the field of environmental protection, nature conservation and climate action in the EU. The aim of the LIFE Program is to contribute to the implementation, updating and development of EU policies and legislation in the field of environment and climate through co-financing of projects that have European added value.

Interreg: European Territorial Cooperation (ETC)

The program was launched with the aim of strengthening the effects of EU Cohesion Policy in the period from 2014 to 2020. The aim is to reduce existing inequalities between EU regions in terms of their economic and social development and environmental sustainability, taking into account their specific spatial characteristics and opportunities. The funds are earmarked for 11 investment priorities, including a low-carbon economy, climate change mitigation, the environment and resource efficiency and sustainable transport.

EEA Financial Mechanism, Norwegian Financial Mechanism and Swiss-Croatian Cooperation Program

Program areas financed from these funding mechanisms are subject to negotiations between the Republic of Croatia and donor countries. The financial perspective for all three mechanisms covers programs with an implementation period until 2024. The EEA Financial Mechanism implements the Energy and Climate Change Program, with the aim of introducing and implementing low-carbon technologies, improving energy efficiency and increasing security of energy supply.

Financing the implementation of measures based on the energy efficiency commitment system according to Directive 2012/27/EU on energy efficiency

Energy suppliers are obliged to implement energy efficiency measures at final consumers. The objectives are set by the Energy Efficiency Commitment System. The costs of these measures are expected to be mostly passed on to consumers. If the taxpayers do not achieve the prescribed savings, they will pay a fee to the EPEEF. This will be a significant source of funding.

Fee on CO2 emission

In the Republic of Croatia, there is a fee for CO_2 emissions, for two groups of sources. The fee is paid by individual stationary sources, from which CO_2 is emitted into the air in the amount of more than 450 tons per year. Charging also exists for ETS plant operators that have emissions of less than 25 kt per year and have been excluded from the ETS, but must implement measures to achieve an equivalent contribution to the emission reduction with verified emissions.

Fee on electricity generation from renewable energy sources

The amount of the fee for encouraging the electricity generation from renewable sources is 0.1050 HRK/kWh + VAT for all electricity customers. Exceptionally, for electricity customers who, in accordance with the Act on Climate Change and Ozone Layer Protection, are required to obtain a permit for greenhouse gas emissions, it amounts to 0.021 HRK/kWh. Incentive fee funds are used to pay the incentive price of electricity to eligible producers who are in the system of incentives for electricity generation, for delivered electricity in accordance with the provisions of the tariff system for electricity generation from renewable energy sources and high efficiency cogeneration (so-called feed-in tariffs).

Credit lines of commercial banks

Numerous commercial banks have included various credit lines and financing models in their offers, as a basis for a strategic commitment to offer financial solutions for energy efficiency and renewable energy projects and to increase participation in this growing energy market.

ESCO companies

ESCO (Energy Service Company) is a business model in which the company invests its own funds, labour and technology, and is charged exclusively from part of the calculated energy savings.

Crowdfunding

Crowdfunding means financing projects by raising funds from a large number of people, which has become simple with the development of the Internet, and are often intended for socially useful projects. There are four basic types of crowdfunding with respect to return on investment to donors, and platforms are based on donations, rewards, borrowing or equity. Crowdfunding is already used in Croatia as a way of financing projects in the energy sector.

Public-private partnerships

European partnerships and missions within the Horizon Europe framework

European partnerships are initiatives in which the EU, together with private and/or public partners, is committed to jointly supporting the development and implementation of research and innovation activities. For the Republic of Croatia there is a possibility to participate in all public-public or public-private partnerships, which are carried out within the EU Framework Program for Research and Innovation - Horizon Europe, with 30-50% of the total funds allocation. Partners can be representatives of industry, universities, research organizations, bodies at local, regional, national or international level, or from civil society organizations, including foundations and NGOs. Joining the partnerships requires the investment of certain national funds, either relevant ministries or other state and public administration bodies or companies that enter as a partner. Other platforms in the field of research and innovation through which support and cooperation can be achieved are, for example, the Knowledge and Innovation Communities (KICs), which are implemented within the European Institute of Innovation and Technology (EIT), the European Innovation Partnerships (EIP), and cooperation programs such as COST and EUREKA. An opportunity for cooperation and networking is a completely new instrument within Horizon Europe, namely missions, a kind of "megaprojects" at the EU level that have high ambitions and high visibility in order to find solutions to some of the main challenges facing European citizens (the areas of mission include Adaptation to Climate Change, including Social Transformation, Cancer, Healthy Ocean and Water, Carbon Neutral and Smart Cities, and Soil Health for Sustainable Food.

7.2.1. New financial perspectives of the European Green Plan

The European Green Plan (2019) is a new growth strategy that seeks to transform the EU into a just and prosperous society with a modern, resource-efficient and competitive economy in which there will be no net greenhouse gas emissions in 2050 and in which economic growth is not resource-intensive. In addition, it seeks to protect, preserve and increase the EU's natural capital and to protect the health and well-being of citizens from environmental risks and environmental impacts, with a fair and inclusive transition.

In early 2020, the EC presented a Sustainable Europe Investment Plan to help secure the necessary additional funding. The European Green Deal Investment Plan will mobilize EU funds and create a framework to facilitate and stimulate public and private investment, which is needed for the transition to a climate-neutral, green, competitive and inclusive economy. The Plan complements other initiatives announced under the Green Plan, and includes three dimensions:

- Financing: sustainable investments worth at least € 1 trillion will be mobilized over the next decade. The largest amount from the EU budget so far will be allocated for actions in the field of environment and climate, which should also attract private investments, and the European Investment Bank will play the main role.
- Favourable conditions: incentives will be provided to attract and redirect investments from the public and private sectors. The EU will help investors by prioritizing sustainable financing, and will make sustainable investments easier for public bodies by encouraging green budgeting and green public procurement. In addition, it will simplify the procedures for granting state aid to regions where a fair transition is needed.
- Practical support: The Commission will assist public bodies and project promoters in planning, designing and implementing sustainable projects.

The fair transition mechanism is the most important tool for a fair transition to a climate-neutral economy, where no one will be neglected. Although all regions will need financial assistance, as foreseen in the European Green Deal Investment Plan, under the 2021-2027 mechanism, at least € 100 billion will be mobilized in the form of targeted support to mitigate the socio-economic consequences of transition in the most affected regions. The mechanism will encourage the necessary investments to help communities that depend on the fossil fuel industry.

The fair transition mechanism will include three main sources of funding:

1. The Fair Transition Fund, for which new EU funding of € 7.5 billion will be allocated and which is one of the priorities in the EC proposal for the next long-term EU budget. In order to be able to withdraw their share of the Fair Transition Fund, Member States must, in dialogue with the EC, draw up territorial plans for a fair transition and identify the territories in need of assistance. Grants from the Fair Transition Fund are primarily intended for the regions. In particular, support will be provided for the development of skills and competences for the labour market of the future and will help to create new economic opportunities in these regions. Investments in the transition to clean energy, such as investments in energy efficiency, will also be supported.

2. A special program for a fair transition within the InvestEU program, which will mobilize investments worth up to € 45 billion. The aim is to attract private sector investment, including investment in sustainable energy and transport, to provide new sources of growth for economies in these regions.

3. The Public Sector Crediting Instrument, with the involvement of the European Investment Bank, supported by the EU budget, will enable the mobilization of investments in the amount of € 25-30 billion. This instrument will provide loans to the public sector, for example for investments in district heating networks and building renovation.

The fair transition mechanism does not only offer funding: through the Fair Transition Platform, the EC will provide technical support to Member States and investors and involve relevant communities, local authorities, social partners and NGOs. The fair transition mechanism will include a strong governance framework, based on territorial plans for a fair transition.

The Republic of Croatia needs to strengthen its capacity to implement new financing instruments, including timely and quality planning and programming of funds and financing programs at all levels in order to use the available funds efficiently and purposefully to achieve the set goals. In addition, it is necessary to ensure the financing of the preparatory phases of projects based on the experience of good practice in the world.

The key to financing in the period up to 2030 will be the extent to which climate activities will be represented in the Republic of Croatia Partnership Agreement and operational programs for the use of EU funds for the financial period 2021-2027.

7.2.2. Funds related to the solidarity assistance to states related to the consequences of the COVID-19 pandemic

Europe and the whole world are facing a health crisis that is turning into an economic crisis like no other. The European Union is responding to the crisis with a solidarity fund to recover the economy and preserve jobs. The Republic of Croatia is recognized as particularly vulnerable. The planned European Union assistance through the Solidarity Recovery Fund reaches an amount of about twenty percent of Croatia's annual GDP. Investments in the green economy and digitalisation will be supported, which will be an additional impetus for the transition to a low-carbon economy. From the point of view of greenhouse gas emissions, the necessary priority interventions in transport, energy-intensive industry, buildings and renewable energy sources have been identified.

8. SCENARIO IMPACT ON ENVIRONMENT, ECONOMY AND SOCIETY

8.1. IMPACT ON ENVIRONMENT AND NATURE

Although the implementation of the Low-Carbon Strategy has a positive effect on reducing greenhouse gas emissions, some aspects of Low-Carbon development pose a potential threat to certain components of the environment and nature. Examples are: the use of renewable energy sources for electricity and/or heat generation and the construction of cogeneration plants, permanent storage of carbon dioxide and activities that may lead to direct or indirect change in the use and/or utilization of agricultural and forest land and space as a whole (reduction of the clinker share in cement production, the use of alternative fuels - biofuels in transport, the introduction of new agricultural species, including the planting of energy crops, the implementation of hydromelioration interventions and disaster protection systems, etc.).

In accordance with the regulations governing environmental protection, the Low-Carbon Strategy is subject to a strategic environmental assessment procedure, which, among other things, assesses the likely significant environmental impacts that may arise from the implementation of the Low-Carbon Strategy. In accordance with the procedure of the preliminary assessment of acceptability for the ecological network, within the strategic assessment, the main assessment of the acceptability of the Low-Carbon Strategy for the ecological network is also carried out. The strategic assessment shall be carried out during the drafting of the Low-Carbon Strategy proposal, prior to the determination of its final proposal and the referral to the adoption process, to ensure that the essential elements of environmental and nature protection are included in the Low-Carbon Strategy. Environmental protection measures and mitigation measures for the ecological network from the strategic assessment process are included in the Low-Carbon Strategy and are listed in Chapter 14.4.

Regarding specific projects - interventions, plans and programs that will result from the implementation of the Low-Carbon Strategy, regulations in the field of environmental and nature protection determine in which cases procedures are carried out in which environmental and nature protection issues are considered, based on more detailed data on interventions, plans and the programs and features of the locations where they are planned. In addition to these procedures, the environmental and nature protection is carried out through the conditions of a number of other regulations such as regulations governing physical planning, construction, protection of agricultural land, protection of cultural property, etc. Thus, environmental and nature impacts arising from strategies will not only be considered once in a strategic environmental impact assessment, but will also be considered and implemented further, through a series of procedures and obligations arising from regulations governing environmental and nature protection and other areas.

8.2. IMPACT ON ECONOMY

The impact on economy is manifested through complex structural changes. On the positive side, economic activity, employment and innovation are growing in sectors that produce clean energy, invest in energy efficiency, as well as in parts of the economy that will actively participate in sustainable waste management and the circular economy. Related to this are significant long-term investments that also have multiplier effects. On the negative side, there is a certain increase in energy costs and the associated decline in economic activity, and there is a gradual decrease in employment in sectors and activities that use traditional technologies based on fossil fuels.

It is important to take into account that the Republic of Croatia receives significant financial funds from the European Structural and Investment Funds and mechanisms within the ETS. In general, the revenues that the Republic of Croatia can generate from EU funds exceed the contributions to the EU budget. All of these revenues help economic growth without the need for indebtedness growth, and funds are invested in sustainable projects that return on investment. Additional funds that will be available for economic recovery and job maintenance due to COVID will be allocated depending on the vulnerability of the sector. Green jobs and digitalisation will be promoted.

With the energy transition, the focus of costs shifts from fuel costs to investments

With low-carbon developments in the energy system, the focus of costs shifts from fuel procurement costs to investment costs. Continuous investment will be needed to achieve cost-effective low-carbon development in the long run. Investments must be initiated primarily in the sectors of direct energy consumption - households, services, transport and industry. Given the development of competitiveness of renewable energy sources and the impact of direct consumption measures on lower energy demand, costs in the energy transformation sector may be lower than in the NUR scenario, because there are savings in the oil and gas sector (significantly after 2030) and less electricity consumption. Costs can also be significantly higher in the case of strong electrification in the transport sector and higher electricity consumption.

Increase of unit energy costs and reduction of energy consumption

The increase of energy prices from fossil fuels, as a rule, has a negative impact on the economy depending on imports, but encourages the application of energy efficiency measures and the use of RES, and the energy transition reduces the economy's sensitivity to import prices of fossil fuels.

The increase of energy prices for end customers have a negative impact on citizens' personal consumption, but will further encourage energy efficiency measures and the development of small integrated photovoltaic systems for own consumption.

It is necessary to identify energy-intensive industry sensitive to rising energy prices and vulnerable energy customers (energy poverty) and to develop programs to reduce the burden and strengthen resilience for industry and vulnerable customers. The focus of the measures should be on the application of energy efficiency measures and RES for own consumption, in order to reduce the sensitivity to the increase of market prices.

Sustainable waste management and the circular economy lead to savings in raw materials

According to the current practice of waste management, over 72% of waste was disposed in landfills. There are estimates that in just ten years, raw materials such as glass, paper, plastic and metals worth over 5 billion HRK have been thrown away.

Recyclable waste and biowaste are collected separately at the place of origin for the purpose of recovery or recycling and are transported to waste management facilities, where they are treated by various recovery processes in order to produce raw materials, alternative fuels and/or products.

Production waste management, in accordance with the Republic of Croatia and the EU legislation and in accordance with the principles of the circular economy and bioeconomy, opens numerous opportunities for energy (but also material) recovery of waste for the industrial sector, which can use its own waste as energy source for its production processes.

Circular management of space and buildings, according to which existing spaces and buildings represent essential resources, enables the retention of their value because space and buildings are used efficiently and continuously, the ratio of primary and secondary resources is optimized, waste is radically reduced, energy consumption and materials use are rationalized, it prevents waste generation, recycles and reduces the amount of hazardous chemicals, and new materials and technologies are being developed. Consequently, the measures are expected to ensure economic stability based on independence from primary raw materials, economic growth based on higher material values and an increase in the employment rate.

Opportunities for innovation and industry development

Low-carbon development is opening up new market niches. Involving domestic industry in new development areas is an opportunity to develop innovation, competitiveness and industrial development that can be a powerful generator of GDP growth and employment.

New policies of low-carbon, energy and industrial development, smart specializations as well as all others, need to be harmonized in order for Croatian companies to achieve the competitiveness needed to manufacture equipment and devices and provide services related to low-carbon development in our and international markets. It is necessary to direct investments in the production of equipment and devices for chemical recycling of waste, and the production and processing of fuel from waste.

Impact of ETS objectives

The Market Stability Reserve (MSR) introduced by the EU contributes to the predictability of emission allowance prices, which will accelerate the implementation of measures to reduce greenhouse gas emissions. Costs for emission allowances in the period from 2020 to 2030 will affect the competitiveness of Croatian operators, and could reach 0.5% of GDP in 2030, if the allowance price is higher than 30 EUR/t CO_2e. The ETS industry can implement a number of cost-effective measures, which will be more cost-effective than buying allowances, as most measures cost less than 30 EUR/t CO_2e.

It is necessary to start as soon as possible with the implementation of measures, plants modernization, reduction of total energy consumption and application of renewable energy sources. Existing incentives and incentive mechanisms are insufficient. Aid to industry is limited by the rules on the granting of state aid. It is necessary to establish incentive programs to reduce emissions that will encourage and mobilize industry to take action and prepare financing schemes for the use of funds from the Modernization Fund (part diverted from the ETS auction rights).

8.3. IMPACT ON SOCIETY

The sociological impact is primarily related to employment, the positive impact of public revenues generated by benefits on CO_2 emissions. The benefits to society avoid adverse health effects due to reduced emissions of SO_2, NO_x and particulate matter.

Jobs

By applying low-carbon technologies, the so-called ‘green’ jobs are opening. These are new and existing jobs that will be reoriented to ‘green’ jobs. Certain existing capacities (from, for example, construction and installation works) can be relatively easily reoriented to green jobs, while in some areas new knowledge and specializations will be required.

The planned investments in low-carbon development will have the greatest impact on the growth of construction, industry and services. In the initial years, about 40,000 new employees are expected, of which about 44% in construction, about 33% in industry, and the rest of about 23% in services. It is to be expected that employment growth will not have the same dynamics in the coming years due to the growth of worker productivity, application of new technologies, transfer of workers from completed works to new works, etc.

Availability of energy

According to analyses of household consumption, almost 20% of households in the Republic of Croatia spend significantly more than 10% of total personal consumption expenditure on energy (electricity, gas and solid fuels). It is necessary to link the programs for the implementation of individual energy policy measures and the application of new technical and technological solutions with measures to reduce energy poverty, and in that sense it is necessary to develop, adopt and implement a program for combating energy poverty. This would enable a lasting reduction in energy costs in energy-poor households, improve their living conditions and reduce the allocations needed to provide assistance to such households.

8.4. ASSESSMENT OF LOW-CARBON DEVELOPMENT BENEFITS

Low-Carbon development will lead to changes in the economy and society in relation to the development according to the reference scenario. Table 8-1 lists the main benefits and challenges related to environmental, economic and social impacts due to Low-Carbon development.

Table 8-1: Main positive and negative impacts of Low-Carbon development

Sector\Impact	Benefits	Challenges and risks
Environment	• Reduction of pollutant emissions • Reduction of waste disposal	• Environmental impact of RES • New types and quantities of waste
Economy	• Initiating investments in Low-Carbon measures • Use of EU funds for investments • Reduction of energy products imports • Lower resource consumption due to sustainable waste management • Creating new "green" jobs • Incentives for technological development and innovation • Avoiding the air pollution and associated health benefits • Climate change mitigation and related consequences	• Costs for subsidizing certain investments in Low-Carbon measures • Cost for plants - sources of greenhouse gas emissions and activities sensitive to rising costs of their products • In the long run, less investment in fossil fuel consumption sectors
Society	• Reduction of health problems due to lower emissions of pollutants • Creating new "green" jobs • Possibility of active participation of citizens as buyers and producers of energy • Development of ways of thinking and acting with the aim of reducing the carbon footprint	• In the long run, fewer jobs in the fossil fuel sectors • Risk of energy poverty due to increase of energy costs

The overall expected benefits for society (taking into account external costs) are positive and result in a lower overall social cost. The main challenge of implementation and dynamics of change is the need for high investments, which can pose a significant challenge for certain segments of the economy and/or customers. A limiting factor of an accelerated transition may be the ability of the economy, society and

individuals to participate in the processes in a timely manner, due to large initial investments, regardless of the fact that the transition processes bring long-term benefits to society and the environment.

To ensure the overall net benefits and at the same time reduce emissions and stimulate economic development in the Republic of Croatia, the key will be:

- to make maximum use of available funds from EU funds;
- to encourage research, innovation, technological development and participation of domestic industry;
- education and changes in the way of thinking and acting and active involvement of citizens;
- to maximize the effects of available funds through innovative financing models.

Low-Carbon development can bring net benefits to society, but additional EU funds are needed to implement the measures.

9. EDUCATION AND ACTIVE INVOLVEMENT OF CITIZENS INTO THE LOW-CARBON DEVELOPMENT

Education, skills acquisition and lifelong learning according to the principles of sustainable development and Low-Carbon Strategy

The education system should become a leader in promoting the principles of Low-Carbon development. Young people entering education today will be the bearers of change in the future, without their knowledge and belief the goals of this strategy will not be implemented. Therefore, this is a priority activity of the Low-Carbon Strategy, more important in the long run than any technical type of measure.

Recognizing the importance of awareness of the complex relationships and connections in ecosystems and human communities and the need for appropriate action in the use of natural resources and sustainable development, the Ministry of Science and Education in January 2019 adopted a Decision on adopting a curriculum on the subject of sustainable development for primary and secondary schools in the Republic of Croatia (Official Gazette, No. 7/19). Since the school year 2019/2020, it has been taught according to the new curriculum and the cross-curricular topic of Sustainable Development encompasses all three dimensions of sustainability: environmental, social and economic, and their interdependence. The national curriculum of the education system promotes sustainable development, integrity, an integrated approach, innovation, planned long-term, understanding of social responsibility and international solidarity.

Furthermore, it is necessary to develop knowledge and skills for the development, implementation and transfer of new technologies and smart solutions, with an orientation towards rapidly developing industries in the direction of a circular economy and a green economy.

The initiation of systematic raising of knowledge about the concept of sustainable development and awareness of climate change should take place through:

- continuous improvement of the level of education on sustainable development and climate change issues in the regular education system (primary school, secondary school, colleges and universities);
- adapting secondary and higher education programs to the learning needed to master the knowledge and skills associated with the Low-Carbon economy and smart specialization;
- lifelong learning through the media (newspapers, television and the Internet) on the principles of the Low-Carbon Strategy that will educate all people, all Croatian residents who are no longer in the process of institutional education of the Republic of Croatia;
- development of application tools for calculating and monitoring the environmental footprint, carbon footprint, for young people, for their activities, for educational institutions, households,

transport. Organizing activities that contribute to reducing the carbon footprint, competitions, test examples of involvement in campaigns, etc.;

- support for the development of centres of educational excellence, support for the development of technology demonstration parks, laboratories, 'living laboratories' such as university campuses. They should be illustrative examples of the complete design of work and living spaces, on which urban planners, energy experts, transport experts, education, natural and humanities experts work together, based on the implementation of advanced technologies and innovative Low-Carbon solutions.

In the period from 2021 to 2030, raising the level of education on sustainable development and climate change in the Republic of Croatia will be supplemented and modernized time after time, and create generations of citizens of the Republic of Croatia who will be fully and systematically "climate aware". Modern media information channels (television and social networks), as fast and attractive transmitters of information and knowledge, will be extremely important. During this period, the first centres of excellence and technology parks will be established, the realization of experimental university campuses and examples of new practice will begin.

Therefore, the National Plan for the Development of the Education System for the period from 2021 to 2027 should be oriented towards building knowledge and developing technologies that will enable the transition to a Low-Carbon economy and a society resistant to climate change.

Changing sociological perceptions and patterns of behaviour

The climate change issue has been slowly but surely entering the public horizon of Croatian society in the last fifteen years. Further affirmation of this topic depends to a significant extent on the effective implementation of the Low-Carbon Strategy in practice. To date, the average citizen has had low awareness of climate issues, passivity in understanding the problem and inadequate, internal, predominantly - conscious or unconscious – high carbon behaviour.

Under the influence of the increasing negative consequences of climate change around the world, there is a change in perceptions and patterns of behaviour of citizens and all actors who make development decisions in the direction of development of the Republic of Croatia as a Low-Carbon society. The changes are directly related to the systematic and quality education and awareness of young people and other citizens of the Republic of Croatia about climate change, which is also contributed by the awareness of the increasing impacts of the negative consequences of climate change in Croatia and around the world. The use of the experience of developed European countries that are at the forefront of the climate awareness process is of significant benefit.

In the period until 2030, a faster change in the way of understanding and patterns of behaviour in the direction of the Republic of Croatia as a Low-Carbon society is envisaged. Processes in the European environment and the world will be further globalized and similar. On one hand, awareness of climate issues will grow systematically, on the other hand new skills will need to be educated that will be able to respond to the challenges of transition to Low-Carbon development, and thirdly, patterns of behaviour will change by applying Low-Carbon practical solutions in social life organization, production, consumption and development management in the direction of increasing sustainability.

10. RESEARCH, TECHNOLOGICAL DEVELOPMENT AND INNOVATIONS

Low-Carbon development needs to be integrated into high-tech innovation, research and development programs in the private and public sectors. The Republic of Croatia lags behind other EU countries in financing research, development and innovation, which is around or over 3% of GDP. In the Republic

of Croatia, HRK 3.7 billion was spent on research and development in 2018, which is 17.8% more than in the previous year, but the share of research and development expenditures in GDP in 2018 was is 0.97%. In the Republic of Croatia, HRK 4.5 billion was spent on research and development in 2019, which is 19.7% more than in the previous year, but the share of research and development expenditures in GDP in 2019 was 1.11%. Research and development are among the biggest potential factors contributing to GDP growth, right after employment increases, so Croatia needs to increase research and development expenditure, closer to the EU average.

In the Republic of Croatia Smart Specialization Strategy for the period until 2020, two horizontal themes are defined along with five thematic priority areas, which represent intersectoral technologies and processes and serve as growth drivers within thematic priority areas, namely key development technologies and information and communication technology. Key development technologies enable the transition from a traditional economy to a low-carbon, knowledge-based economy. They play an important role in developing, innovating and strengthening the competitiveness of the industry, and include biotechnology, micro and nano-electronics and photonics, and other advanced materials and technologies. As the Smart Specialization Strategy is one of the fundamental strategic documents in the field of technological development and innovation, this created the initial preconditions for the transition to a Low-Carbon economy and for involvement in this process, institutions responsible for supporting business investment in research, development and innovation.

The new EU Framework Program for Research and Innovation 2021-2027, Horizon Europe, plays a key role in shaping, supporting and implementing European policy priorities, including the European Green Plan, to which research and innovation should contribute horizontally. It is projected that more than 35% of the total funding within Horizon Europe will contribute to achieving the objectives of the Green Plan. In accordance with this EU definition, it is proposed that 30% of all national investments in science in the Republic of Croatia must be related to "green research", i.e. research that contributes to achieving the goals of the European Green Plan.

Some of the specific measures for Low-Carbon technological development, innovation and research may be:

- co-financing of industrial research and experimental development projects complied with the Smart Specialization Strategy and the Low-Carbon Strategy
- co-financing the development of entrepreneurship in the field of smart specialization and Low-Carbon economy
- enabling the acquisition of domestic references through a model of joint development with the public sector
- recognizing the topic of climate change as an interdisciplinary field of science in determining the criteria and conditions for acquiring the scientific status of legal and natural persons.

The research is required for the following topics:

- development of models, methods for integrated carbon management, for improvement of emission/sink calculations, for emission/sink projections, for application of total life cycle calculation
- research of technologies, technical and non-technical measures to reduce emissions and increase sinks in all sectors (energy, transport, agriculture, forestry, waste and industrial processes)
- research into the possibilities of use, methods of storage, transport and geological storage of CO_2
- research into the links between climate change mitigation and adaptation, and interaction with other components of the environment
- development of integrated models for assessing the effects of climate change mitigation policies and measures on the economy, society and the environment

- research on sociological aspects of climate change, development of models and methods for promoting and raising public awareness on climate change
- research to improve education, smart specializations and lifelong learning as part of the response to the challenge of climate change mitigation
- research into funding models, in particular potential public-private partnership models
- research into the potential of biomass, biogas, synthetic gas and hydrogen derived from waste, production of biomass, biogas, synthetic gas and hydrogen, use of biomass and related socio-economic aspects
- research into the potential of renewable energy sources, the costs and benefits of their use, their impact on the environment, nature and the ecological network
- research of technology and potential in the production of synthetic methane and hydrogen in the process of natural gas decarbonization
- studies of integrated solutions, energy efficiency, renewable energy sources in all sectors, optimization models for smart cities, green cities and urban infrastructure;
- research on advanced networks and smart systems
- development of smart city concepts and planning
- research related to the construction of a circular economy, the introduction of a management system for the use of resources, energy and carbon footprint
- research on sustainable urban mobility, cooperative, intelligent and automated transport solutions
- research on the possibilities of increasing carbon storage on agricultural land and potential innovative measures in animal husbandry.

Particular technological progress is expected in the application of ICT technologies in all sectors, especially with great impact in energy and transport. The development of energy storage systems, infrastructure for electric vehicles and batteries, autonomous systems in various sectors and robotics will play a decisive role.

Financial support is needed for all projects applying for Horizon Europe and the LIFE program, which increase the knowledge needed to create a green and competitive Low-Carbon economy in which resources will be used more efficiently.

As in the previous period, the main source of funding will continue to be ESI funds and funds raised at the auction of CO_2 emission allowances. The initial preconditions for the transition to a Low-Carbon economy were set by the adoption of the Republic of Croatia Smart Specialization Strategy, and the main part of the funds for the Strategy implementation is provided from the European Structural and Investment Funds. In addition, an available source of funding will be funds from the ETS for modernization and a financial mechanism to support innovation for the period 2021 to 2030, in ten EU Member States which GDP per capita at market prices was below 60% of the EU average, which includes the Republic of Croatia. The European Green Plan recognizes the need to provide additional funding for research, technological development and innovation. The state will increase investment in research, development and innovation and investment in knowledge and technology transfer and the development of knowledge and innovation-based technologies, through various programs, from grants, through conditional loans to state aid programs.

11. LOW-CARBON DEVELOPMENT AT LOCAL AND REGIONAL LEVEL

Cities are increasingly becoming centres of economic and social activities as a result of continuous urbanization and the increasing trend of societies transition into knowledge-intensive economies. As a

result of these changes, resource consumption is increasing in cities, which inevitably leads to an increase in emissions.

In addition there is an overview of climate change mitigation policy instruments at the local and regional levels.

Physical and urban plans

One of the most important instruments for the implementation of climate policies is physical and urban planning, given that physical plans have the force and legal nature of bylaws. The principle of an integrated approach to physical planning only ensures the optimal synergy effect of sectoral policies and Low-Carbon development measures in order to reduce emissions. The planning paradigm aimed at Low-Carbon or non-carbon development and decarbonization is the starting point for a new generation of physical plans.

Smart cities

The realization of the concept of "smart cities" should also contribute to the reduction of greenhouse gas emissions at the local level. The concept refers to the application of integrated technological solutions that generally enable higher quality of public service to citizens, better use of resources and less impact on the environment in cities. Investments in the development of information and communication technologies in the EU, in this sense, are, among other things, placed in the function of meeting the objectives of the climate and energy package.

In order to accelerate the application of these technologies, the European Commission has initiated the "European Innovation Partnership on Smart Cities and Communities". The partnership focuses on sustainable urban mobility and infrastructure integration in the areas of energy, information and communication technology and transport. The partnership was not initiated primarily to reduce greenhouse gas emissions, but the implementation of solutions for "smart cities" undoubtedly results in reduced energy consumption, more efficient use of resources and reduced emissions in cities.

As part of the partnership, EU cities are invited to highlight their commitments to secure funding and develop smart city solutions. So far, more than 3,000 partners have been involved, including commitments highlighted by four Croatian cities: Zagreb, Rijeka, Osijek and Dubrovnik.

Cities should base their planning on energy planning at the level of the entire city and city districts, so that optimal solutions can be obtained.

The Horizon Europe mission will help meet the objectives set by international policy frameworks, such as the Paris Agreement, the UN Sustainable Development Goals (especially SDG 11 and 13), the Urban Agenda for the EU and the New Urban Agenda Habitat III, since the cities play a key role in all of them. Reaching 100 climate-neutral cities by 2030 is a goal set by the Mission Board for climate-neutral and smart cities. The mission in this area would support, promote and indicate 100 European cities in their systematic transformation towards climate neutrality by 2030 and turn them into a hub of experimentation and innovation for all cities.

Smart islands

At the initiative of island units of local self-government and other stakeholders on the islands, with the aim of developing smart, inclusive and successful island communities for an innovative and sustainable Europe, a declaration on smart islands was signed in 2017. The declaration emphasizes the need to encourage island communities to switch to clean energy and, in particular, to strengthen synergies between energy, transport and information and communication technology, including water and waste issues. This approach is based on ensuring the optimal use and management of island resources and contributing to sustainable and balanced development that will maximally preserve and exploit the island's potential. One of the main determinants of smart islands is reducing the use of fossil fuels,

increasing the use of significant renewable energy resources and energy efficiency. The goal of using renewable energy sources, sun, wind, sea currents and waves is Low-Carbon development, which contributes to increasing the energy efficiency of residential buildings (lighting, heating, cooling) and infrastructure (street lighting, pumping stations, ...). The potential of the island as a pilot site for the development of integrated solutions such as energy production from waste and wind and sea energy, the use of energy produced from renewable energy sources in transport and electric vehicles or for desalination, using synergies between sustainable energy, waste, water and mobility is particularly emphasized.

Climate change mitigation, climate change adaptation and ozone protection program

The Act on Climate Change and Ozone Layer Protection (Official Gazette, No. 127/2019) stipulates the obligation of representative bodies of counties, the City of Zagreb and large cities to adopt a program for climate change mitigation, adaptation to climate change and protection of the ozone layer as an integral part of the environment protection program.

The obligation to develop the program is prescribed for 20 counties, the City of Zagreb and a dozen large cities in the Republic of Croatia (cities with more than 35,000 inhabitants).

Initiative Covenant of Mayors for Climate and Energy

One of the instruments in the implementation of the EU climate and energy policy is the Covenant of Mayors initiative for climate and energy.

In 2008, the European Commission launched the Covenant of Mayors initiative, in order for local governments to be actively involved in the energy transition with the aim of achieving the EU's climate and energy goals - the 20-20-20 goals by 2020. In this way, a network of aware local self-government units has been created, committed to the sustainable energy development of the local environment and the preservation of the environment, which serves the well-being of all EU residents.

Following the adoption of the Paris Agreement on Climate Change in 2015, consultations on the future of the Covenant of Mayors were held within the framework of European climate policy, and the Covenant of Mayors for Climate and Energy was launched, which goes beyond the 2020 targets. The signatories of the Covenant of Mayors for Energy and Climate undertake to:

- reduce carbon dioxide (and, where possible, other greenhouse gases) emissions in their cities or municipalities by at least 40% by 2030 through more efficient use of energy and greater use of renewable energy sources;
- increase resilience, adapting to climate change and
- share their vision, results, experience and knowledge with other local and regional authorities inside and outside the EU, through direct cooperation and exchange, especially in the context of the Global Covenant of Mayors.

To this end, the signatories of the new Covenant of Mayors for Climate and Energy undertake to develop and implement the Sustainable Energy and Climate Action Plan (SECAP), which, in addition to sustainable energy development measures, which results in the reduction of greenhouse gases, determines the climate change adaptation measures in accordance with local specifics.

Charter of Cooperation for the Decarbonisation of Buildings by 2050

The Charter of Cooperation for the Decarbonisation of Buildings by 2050, launched by the Ministry of Physical Planning, Construction and State Assets, Construction and State Property, supports the EU's vision of decarbonising buildings by 2050. The charter was launched for better communication and cooperation between public administration bodies and the real sector. The goal is through workshops and open dialogue of partners, to create a wide network of connected experts who are ready for a joint dialogue and contribution to the decarbonisation of the building stock by 2050. Open dialogues of

partners bring together representatives of state administration, local governments, academia and the professional public, construction and energy sectors and related industries, at thematic workshops organized by the Ministry of Physical Planning, Construction and State Assets.

The content of the charter refers to achieving energy and climate goals at national and EU level through decarbonisation of the building stock, renovation of buildings and construction of almost zero energy buildings, aware of the importance of further reducing greenhouse gas emissions, increasing the share of renewable energy sources, improving energy security and innovation and smart technologies, which allow buildings to support the overall decarbonisation of the economy.

Low-Carbon regional and local integrated systems

When planning the development and investment in infrastructure in the field of energy, transport and information and communication technology, at the level of cities, local and regional communities, it is necessary to analyze the possibilities of establishing integrated solutions, in which these sectors would be interconnected. By combining advanced information and communication technologies with energy and transport systems, it is possible to achieve multiple positive effects by contributing to the Low-Carbon development of local and regional communities. Through integration projects, it is necessary to establish strategic partnerships between communities and industry and get acquainted with the possibilities of today's technologies. Project planning needs to be approached holistically.

Innovative solutions should be sought through alternative forms of energy, improvement of public transport, efficient logistics and planning, increasing the energy efficiency of buildings and populated areas, increasing the share of renewable energy sources and raising the overall efficiency and sustainability of urban systems. Solutions should make a measurable contribution to reducing energy consumption, increasing energy efficiency and increasing the share of renewables in energy production.

A special case of integration is inhabited islands, some of which have already launched energy independence projects on their own. As in the case of regional and local communities, when planning the development of infrastructure on islands, it is recommended to analyze the possibilities of establishing integrated solutions, mostly with the aim of creating energy independence, i.e. islands with almost no CO_2 emissions. This mostly applies to energy production, transport and waste. Moreover, it is desirable to establish stronger cooperation between the islands in order to exchange experiences on the initiated projects and to incorporate Low-Carbon development goals into the development policy of Croatian islands by the competent ministry.

One of the potential sources of funding for the establishment of integrated solutions is the mechanism of integrated territorial investments (ITU) of structural funds, which allows Member States to implement a cross-sectoral integrated development strategy in a given territory and a combination of investments from several priority areas, from one or more operational programs.

The competent authority for climate policy, the Ministry of Economy and Sustainable Development, will, in its coordinating role, establish better coherence and synergies between policies. Action is increasingly shifting to independent activities of local governments and cities. More ambitious initiatives such as carbon neutral islands, cities and the like should be supported.

In urban centres and protected areas of cultural heritage, district heating and cooling systems should be promoted. Facade gas boilers, split air conditioning units, gas meters on the building facades, electric meters on the building facades, damage the urban landscape, and urban plans and the law on landscape should make progress in this regard.

12. LOW-CARBON ECONOMY AND BUSINESS MODELS

Development of the circular economy

It is necessary to implement a policy of sustainable consumption and production under the slogan "do more and better with less", to encourage sustainable patterns of behaviour and business in all economic sectors. The concept of “life cycle assessment” (LCA) should be followed, which monitors the environmental footprint of products and services and is based on scientific indicators. The aim is to reduce the consumption of natural resources, reduce the generation of hazardous and toxic substances, reduce emissions to air, water and soil, and reduce or prevent the generation of waste at the place of origin.

At the United Nations Conference on Sustainable Development Rio+20, new impetus was given to sustainable consumption and production policy and voluntary programs, projects and initiatives are envisaged to develop a 10-year framework for sustainable consumption and production programs (10YFP on SCP). Six areas for the development of programs to be implemented by the Republic of Croatia, which contribute to the implementation of the Low-Carbon Strategy, have been identified:

- consumer information;
- sustainable lifestyles and education;
- sustainable public procurement;
- sustainable buildings and construction;
- sustainable tourism, including ecotourism;
- sustainable food.

It is necessary to continue with the activities that have been started, and they can all be specifically aimed at stronger appreciation, promotion and use of the carbon footprint:

- encouraging eco-labelling;
- green public procurement;
- encouraging eco-labelling and control in agriculture;
- energy certification of buildings;
- sustainable tourism and destinations.

Business management of Low-Carbon development principles

The application of the principles of Low-Carbon development in business organizations is mostly voluntary, which means that the leaders of organizations apply these principles, expecting to achieve some benefit in the long run. They can benefit directly, for example, by applying an international energy management standard, thus reducing energy costs, or by certifying products to gain an advantage in public procurement procedures, in which the nature of green services and products is increasingly set as a criterion in bids evaluation. On the other hand, socially responsible business, also based on relevant international standards and guidelines, does not bring direct material benefits, but creates a positive image of the organization in the public, which then the benefits can be realized indirectly.

Therefore, the success of this measure depends on two elements: primarily on raising awareness and educating those responsible for managing organizations and making key business decisions, and on creating a supportive business environment in which organizations will recognize the benefits of Low-Carbon development, taking into consideration that such benefit is not necessarily material or at least can only be materialized in the long run.

Initially, the possibility of co-financing the costs of business adjustment can be analyzed through those international guidelines and standards that result in effects in accordance with the principles of Low-Carbon development. This can be the harmonization of the organization with the requirements for

energy management and environmental protection or with the requirements for the acquisition of signs of integrated production and organic production. Support refers to the introduction of a system of business management, maintenance, assets, anything that can increase resource efficiency.

Promoting carbon footprint products and services

This measure is conducted in strong synergy with the green public procurement measure:

- study research, development of databases, models, methods for calculation and establishment of carbon footprint schemes;
- calculating the carbon footprint of products and services on the Croatian market;
- encouraging projects to establish optional labelling schemes for carbon and environmental footprint products and services;
- encouraging the implementation of the labelling and carbon footprint scheme and its beneficiaries;
- identification of Croatian export products with a possible carbon footprint brand.

Green and Low-Carbon procurement

The Second National Action Plan for Green Public Procurement needs to be expanded with objectives with regard to the specific requirements of Low-Carbon development. It is necessary to define groups of products and services, for which the goal of Low-Carbon public procurement is prescribed, and to quantify the goals. Prior to the adoption of the Second National Action Plan, green and Low-Carbon procurement in the private sector and in the public sector needs to be encouraged for simple procurement procedures.

13. INTERNATIONAL COOPERATION

The basic principle of the UNFCCC is the solidarity of states and the assumption of common but different obligations, according to possibilities. The global product market is becoming more and more market connected, in the EU the electricity and gas market is becoming more and more common, which gives customers more opportunities, lower prices and a more secure supply. Many activities and projects that help reduce emissions can be implemented more efficiently with international cooperation. European policy encourages associations, the transfer of green certificates and gives priority to projects that achieve cooperation and pool capital in investments.

The UNFCCC and the Paris Agreement state the obligation to cooperate and state that the parties, which are developed countries of the world, will assist the parties, which are developing countries, in supporting capacity building measures to mitigate and adapt to climate change. With its membership in the EU, the Republic of Croatia enters the category of developed countries in the world, and through the national policy of international development assistance, assistance programs should be developed for selected parties, which are developing countries, in the field of climate change. In addition, the Republic of Croatia participates in the creation of EU international development assistance, which as a party to the UNFCCC and the Paris Agreement is the largest single donor in the world for climate policy.

In general, there are three types of potential assistance: financing, technology transfer and capacity building.

Assistance through the transfer of knowledge and experience to neighbouring countries, especially candidate countries for EU membership, should be achieved through existing cooperation programs and future projects and programs aimed at transferring knowledge and experience in the field of climate change mitigation and adaptation.

International cooperation also includes active participation in the negotiations on reaching and implementing a global agreement on climate change mitigation and adaptation, primarily through participation in shaping the EU's common position on international climate negotiations.

Cooperation with EU Member States, with co-financing through various EU programs (Interreg, LIFE), is also useful for the purpose of exchanging experience and capacity building in the implementation of EU climate goals and regulations.

14. IMPLEMENTATION OF LOW-CARBON STRATEGY

14.1. INSTITUTIONAL FRAMEWORK FOR IMPLEMENTING THE LOW-CARBON STRATEGY

The Ministry of Economy and Sustainable Development (MESD) is responsible for energy and climate policy. In MESD, the Climate Activities Directorate is in charge of the climate area, and the Energy Directorate is in charge of energy.

The Ministry of Physical Planning, Construction and State Assets is responsible for the area of energy efficiency in buildings and activities related to the decarbonisation of the national building stock.

The MESD establishes the legal, strategic and institutional framework for the implementation of climate policy, it is in charge of financial mechanisms and implements the tasks of organizing the preparation of the national inventory of greenhouse gases; a national report on the implementation of policies and measures to reduce emissions and increase greenhouse gas sinks and a report on projections of greenhouse gas emissions by sources and their removal by sinks; manages the emissions trading system; conducts checks on the consistency of data on activities and emissions of greenhouse and indirect greenhouse gases against comparison with verified emissions; report on the issuance, accounting, transfer, receipt, cancellation and withdrawal of emission reduction allowances, allocation allowances and removal and transfer allowances for the next binding period in the Union Registry; conducts records and reporting on authorized legal entities participating in emissions trading; coordinates Low-Carbon development policy between sectors and works on horizontal and vertical integration of climate goals; directs investments in Low-Carbon development from funds raised from emission auctions; invests in research and development and information and communication projects; participates in the creation of a common climate policy and EU legislation and participates in international negotiations on the implementation of the UNFCCC and the Paris Agreement.

The activities of the EPEEF include activities related to the financing of the preparation, implementation and development of programs, projects and activities in the field of preservation, sustainable use, protection and improvement of the environment and in the field of energy efficiency and use of renewable energy sources; mediation related to the financing of environmental protection and energy efficiency from the funds of foreign states, international organizations, financial institutions and bodies, as well as domestic and foreign legal and natural persons; maintains a database of programs and projects in the field of environmental protection and energy efficiency and the necessary and available financial resources for their implementation; encourages, establishes and achieves cooperation with international and domestic financial institutions and other legal and natural persons in order to finance environmental protection and energy efficiency in accordance with the Energy Development Strategy, NECP and other programs in the field of environmental protection and energy efficiency and international agreements which the Republic of Croatia is party of.

The State Hydrometeorological Institute (SHI) conducts systematic, professional and scientifically based monitoring of climate and climate change in order to assess the impact of changes in the concentration of greenhouse gases in the atmosphere. The SHI also improves the methods and models

on the basis of which climate change projections are made, taking into account the proposed scenarios of changes in greenhouse gas emissions.

In order to improve cross-sectoral cooperation, two commissions have been established:

- Commission for cross-sectoral coordination for the national system for monitoring greenhouse gas emissions and
- Commission for cross-sectoral coordination for climate change mitigation and adaptation policies and measures.

The Commission for cross-sectoral coordination for climate change mitigation and adaptation policies and measures makes recommendations on overall climate change mitigation and adaptation policies and measures; provides support in the implementation of policies and measures for climate change mitigation and adaptation and evaluates strategic documents related to climate change mitigation and adaptation policies and measures.

The establishment of both commissions has contributed to great progress, improved the flow of information and sectoral involvement in decision-making, and raised the level of knowledge. Further efforts are needed to ensure feedback, and to include climate issues in policy planning and implementation, including at the local level, in some sectors.

Stronger mechanisms for horizontal action are needed to implement the Low-Carbon Strategy. Capacities for work on climate change activities need to be strengthened in several sectors, which would contribute to better recognizing the synergistic effects of climate change mitigation and adaptation policies and measures. Given that the development documents of individual areas and activities must be complied with the principles, basic goals, priorities and guidelines of Low-Carbon development set out in the Low-Carbon Strategy, it is expected that cross-sectoral compliance will adjust the existing legal framework and development documents.

One of the most important instruments for the implementation of climate policies is physical and urban planning, given that physical plans have the force and legal nature of bylaws and given that physical planning is a multidisciplinary activity that unites all sectors. The determinants of physical and urban plans aimed at decarbonization and Low-Carbon development directly affect the preparation of projects and activities in space, and thus the achievement of climate goals for reducing emissions.

Part of the responsibilities and authorities should be located in institutions that already have developed capacities, which will easily accept new functions and which create synergies with their existing tasks. Legal entities with public authority at the state level should recognize the opportunity for development, compete for the management of certain segments of the Low-Carbon Strategy and action plans for its implementation. Jobs that have become unnecessary should be focused on the new jobs offered in administrative terms by the Low-Carbon Strategy.

As already pointed out in the introductory part, for the successful implementation of the Low-Carbon Strategy, in addition to horizontal cooperation, vertical cooperation from the state level to action at the local level is necessary. Local and regional self-government units and legal entities with public authority established by regional and local self-government units must recognize the necessity of Low-Carbon development and understand it as a challenge and a need for economic prosperity and general well-being.

14.2. INDICATORS OF LOW-CARBON STRATEGY IMPLEMENTATION

Indicators for monitoring the implementation of the Low-Carbon Strategy are indicated in Table 14-1.

Table 14-1: Indicators of Low-Carbon Strategy implementation

Objective	Main effects (bold) and outcomes indicator
Achieving sustainable development based on knowledge and a competitive Low-Carbon economy and efficient use of resources	• **Reduction of total greenhouse gas emissions compared to 1990** • Reduction of greenhouse gas emissions per capita, compared to 1990 • **Reduction of greenhouse gas emissions compared to 1990 per GDP unit** • Reduction of greenhouse gas emissions per unit of total energy consumed • Number of new green jobs (monitoring methodology needs to be developed) • Global Competitiveness Index, "infrastructure" component
Increasing security of energy supply, sustainability of energy supply, increasing energy availability and reducing energy dependence	• Total energy consumption • Direct energy consumption • Share of renewable energy sources in gross direct energy consumption • Electricity consumption • Production of electricity from renewable energy sources (% of total electricity production) • **Reduction of energy imports** • Reduction of electricity imports • Share of renewable energy sources in gross total energy consumption
Solidarity by fulfilling the obligations of the Republic of Croatia under international agreements, within the European Union policy, as part of our historical responsibility and contribution to global goals	• **Total greenhouse gas emissions** • Emissions and sinks by sectors (energy system, industry, transport, LULUCF (land use, land use conversion and forestry), agriculture, waste • Greenhouse gas emissions of the ETS sector • **Greenhouse gas emissions of the sector outside the ETS** • Difference in greenhouse gas emissions in relation to the established quota in sectors outside the ETS • Municipal waste recycling rate • Investments in transition implementation measures • Investments in research, development and innovation
Reduction of air pollution and health effects	• Number of cities that have exceeded the prescribed air quality and implement Action Plans to improve air quality, by pollutants

These indicators are complied with the relevant list of national indicators from the Library of Indicators for the Republic of Croatia strategic planning and development management system[3].

14.3. MONITORING, REPORTING AND VERIFICATION

The Republic of Croatia has an obligation to report to the UNFCCC and the European Commission, as well as to a number of other European and international institutions. The competent ministry will improve the monitoring, reporting and verification system by establishing data exchange protocols, working on the establishment of common databases and information systems, defining the formats and contents of reports and reporting calendars. All data and reports related to the area of climate change policy will be validated through the system as indicated in Figure 14-1. The system includes: departments that submit data for the competent area or sectors, local and regional self-government units (LRU), the Central Bureau of Statistics (CBS), the European Environment Agency (EEA), UNFCCC, EC, EUROSTAT, Food and Agriculture Organization (FAO), World Meteorological Organization (WMO), etc.

[3] Act on Republic of Croatia Strategic Planning and Development Management System (Official Gazette, No. 123/17)

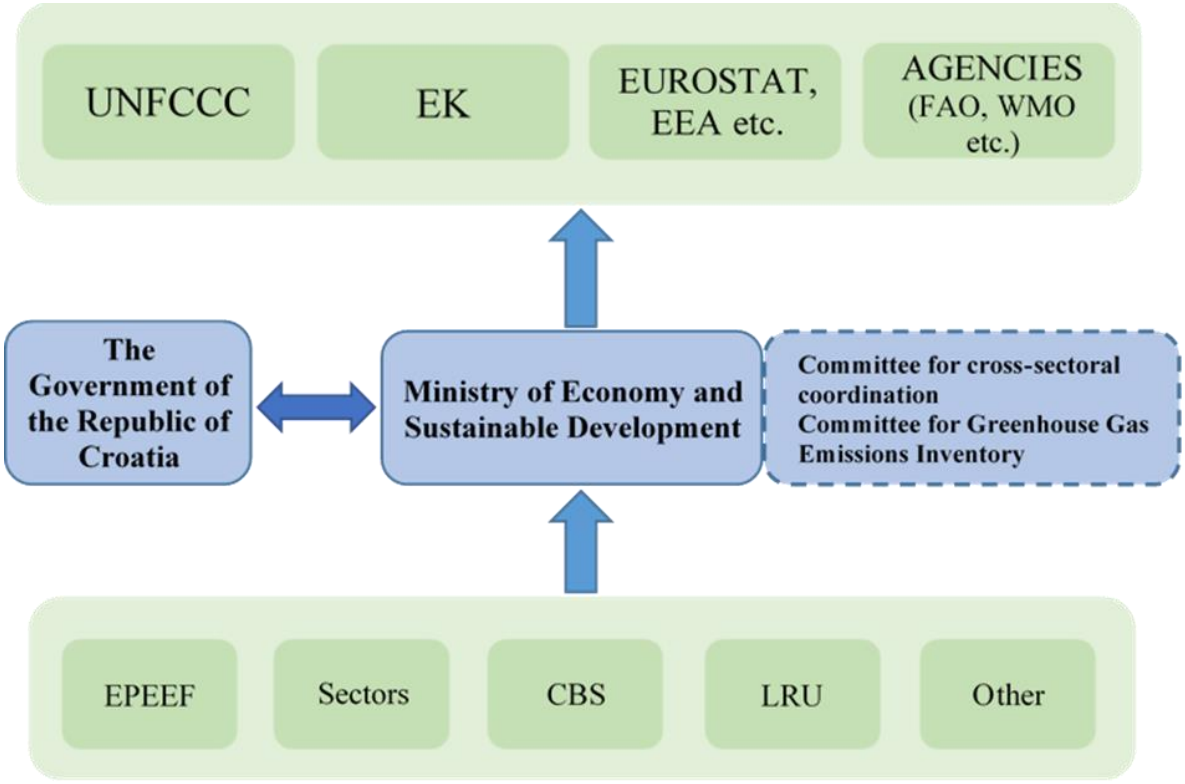

Figure 14-1: Data and reports flow diagram

The Low-Carbon Strategy proposes the introduction of cost accounting for the implementation of the Low-Carbon Strategy, which means, across all horizontal sectors. The EU has a practice of expressing costs for climate activities, within the ESI funds.

In addition to the reports that are part of the climate energy policy, the Strategic Planning and Development Management System of the Republic of Croatia will also be used to monitor and report on the implementation of the Low-Carbon Strategy.

14.4. STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT OF LOW-CARBON STRATEGY

In accordance with the regulations governing environmental protection, a process of strategic environmental impact assessment is being carried out for the Low-Carbon Strategy. The basis for the strategic environmental impact assessment procedure is the Strategic Environmental Impact Assessment of the Low-Carbon Development Strategy of the Republic of Croatia for the period up to 2030 with a view to 2050. Given that the process of strategic environmental impact assessment includes the main assessment of acceptability for the ecological network, the Main Assessment of Acceptability of the Strategy for the Ecological Network is an integral part of the Strategic Study.

The Strategic Study examines the potential impact of the Low-Carbon Strategy on the environment and the ecological network, and identifies environmental protection measures and mitigation measures on the conservation objectives and integrity of the ecological network area. Environmental protection measures are listed in Table 14-2, and measures to mitigate the negative impacts on conservation objectives and the integrity of the ecological network area are listed in Table 14-3.

Table 14-2: Environmental protection measures

Measure	Implementation holder
Planting of "energy" crops in agricultural areas has to be planned in a way that available amount of space for food production is available.	Ministry responsible for agriculture
When selecting new varieties, breeding programs of indigenous species should be encouraged that will respond to the requirements of climate change such as drought resistance and disease resistance.	Ministry responsible for agriculture
When implementing measures within the Agriculture sector, which states: "Improving breeding and selection programs, animal health and welfare," look out for the preservation of genetic diversity to avoid inbreeding.	Ministry responsible for agriculture
Develop guidelines on sensitivity zones for wind farms and develop sensitivity maps of the Republic of Croatia, with regard to birds, bats and marine mammals, and avoid planning of wind farm facilities within high sensitivity zones. Incorporate guidelines into physical plans.	Ministry responsible for energy, Ministry responsible for nature, Ministry responsible for construction works
Develop sensitivity maps of species/habitat types associated with aquatic and wetland ecosystems in relation to the use of hydropower and construction of hydropower plants and avoid planning of hydropower plants within high sensitivity zones. Incorporate guidelines into physical plans.	Ministry responsible for energy, Ministry responsible for nature, Ministry responsible for construction works
Long-term planning the establishment of monitoring systems for injured types and defining the method of exchanging collected data for existing and planned wind power plants.	Ministry responsible for energy, Ministry responsible for nature
Develop guidelines for assessing cumulative impacts of the hydropower plants construction adapted for species and habitat types in the Republic of Croatia. Incorporate guidelines into physical plans.	Ministry responsible for energy, Ministry responsible for environment, Ministry responsible for construction works
When planning hydromelioration projects and disaster protection systems (flood protection) and construction of hydropower plants in drafting the Feasibility study, it should take into account the evaluation of ecosystem services, particularly in terms of their value in preserving floodplain areas that mitigate climate change (natural retention for receiving the flood waves) and binding greenhouse gases (wetlands and	Investor

Measure	Implementation holder
forest ecosystems). This measure will be implemented after the mapping and assessment of the value of ecosystems and drafting the manual for the evaluation of ecosystem services, which will be implemented by the Ministry responsible for nature (until 2023).	
Develop guidelines on sensitivity zones for PV systems and develop sensitivity maps of the Republic of Croatia, with regard to targeted habitat types, and avoid planning of PV systems within high sensitivity zones. Incorporate guidelines into physical plans.	Ministry responsible for energy, Ministry responsible for nature, Ministry responsible for construction works
Develop guidelines for assessing the impact of wind farms, photovoltaic systems and hydropower plants on cultural heritage and cultural landscape, taking into account possible indirect impacts.	Ministry responsible for culture protection
Develop the Landscape Basis of Croatia and determine the standards and criteria for the implementation of typological classification and assessment of the landscape character at all levels (national, regional, local).	Ministry responsible for environmental protection, Ministry responsible for construction works, Ministry responsible for culture protection
When designing the cooling system of cogeneration plants, take into account the negative environmental impacts of thermal pollution and the possibilities to reduce the heat dissipated in surface water.	Investor

Table 14-3: Mitigation measures in Low-Carbon Strategy on the conservation of objectives and integrity of the ecological network

MEASURE	IMPLEMENTATION HOLDER
Develop guidelines on sensitivity zones for wind farms and develop sensitivity maps of the Republic of Croatia, with regard to birds, bats and marine mammals, and avoid planning of wind farm facilities within high sensitivity zones. Incorporate guidelines into physical plans.	Ministry responsible for energy, Ministry responsible for nature, Ministry responsible for construction works
Develop sensitivity maps of species/habitat types associated with aquatic and wetland ecosystems in relation to the use of hydropower and construction of hydropower plants and avoid planning of hydropower plants within high sensitivity zones. Incorporate guidelines into physical plans.	Ministry responsible for energy, Ministry responsible for nature, Ministry responsible for construction works
Long-term planning the establishment of monitoring systems for injured types and defining the method of exchanging collected data for existing and planned wind power plants.	Ministry responsible for energy, Ministry responsible for nature
Develop guidelines for assessing cumulative impacts of the hydropower plants construction adapted for species and habitat types in the Republic of Croatia. Incorporate guidelines into physical plans.	Ministry responsible for energy, Ministry responsible for nature, Ministry responsible for construction works
When planning hydromelioration projects and disaster protection systems (flood protection) and construction of hydropower plants in drafting the Feasibility study, it should take into account the evaluation of ecosystem services, particularly in terms of their value in preserving floodplain areas that mitigate climate change (natural retention for receiving the flood waves) and binding greenhouse gases (wetlands and forest ecosystems). This measure will be implemented after the mapping and assessment of the value of ecosystems and drafting the manual for the evaluation of ecosystem services, which will be implemented by the Ministry responsible for nature (until 2023).	Investor
Develop guidelines on sensitivity zones for PV systems and develop sensitivity maps of the Republic of Croatia, with regard to targeted habitat types, and avoid planning of PV systems within high sensitivity zones. Incorporate guidelines into physical plans.	Ministry responsible for energy, Ministry responsible for nature, Ministry responsible for construction works

With the application of environmental protection measures and measures to mitigate negative impacts on the conservation objectives and integrity of the ecological network area, the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050 is acceptable for the environment and ecological network.

15. INFORMATION ON CLIMATE NEUTRALITY SCENARIO

At the end of 2019, the European Commission presented the European Green Plan, which presented the climate ambition to achieve climate neutrality in the EU by 2050. In December 2020, the European Council adopted an increase of the goal for reducing greenhouse gas emissions at EU level by 2030 to -55% compared to 1990 levels. With this, the EU wants to maintain its leading role in the implementation of international climate agreements, the Paris Agreement and the UNFCCC.

In 2020, work began on the so-called EU Climate Law, which will integrate the aforementioned goal. In order to implement this goal, by June 2021 the EC will present proposals for amendments to EU legislation in the field of climate change and regulations that will regulate the reduction goals for individual sectors of the Member States.

Obligations for the Republic of Croatia until 2030 will be known only after defining all sectoral goals that will ensure the achievement of the common goal of reducing EU emissions, which will be complied and accompanied by changes to all EU sectoral legislation. The commitment to revise the Integrated Energy and Climate Plans is also expected in 2023, in line with the new distribution of emission reduction efforts to Member States and new sectoral targets.

The Republic of Croatia supports the EU climate policy direction and has initiated the process of developing scenarios for achieving greater emission reductions by 2030 (Croatia's share in the common EU target of -55%) and climate neutrality in Croatia by 2050. Given the complexity of the issue, broad public consultation with all sectors and stakeholders on achieving this common EU goal are required.

Scenarios for achieving greater emission reductions by 2030 for the Republic of Croatia have been developed taking into account the current way of allocating efforts to Member States, in such a way that countries with lower GDP have lower goals than countries with higher GDP. This means that the EU has a common goal of -55%, while due to solidarity, countries with lower GDP will have lower goals.

Preliminary analyses of the developed scenarios show that the Republic of Croatia can reduce emissions by 44.8% by 2030, while by 2050 it can achieve a reduction of 89.4% by measures to reduce emissions in all sectors. The remaining part of emissions of 10.6% until achieving climate neutrality, which will not be able to be reduced in some sectors, will be achieved by measures to increase sinks (afforestation, reduction of timber exports, reduction of biomass use for energy purposes, increasing production of furniture and other wood products, agroforestry) and technological measures for carbon capture, use and storage.

These analyses show that in addition to major reform of society, significant public and private financial resources are needed. For example, for the energy sector alone, 103.5 billion HRK will be needed by 2030 in the scenario of existing measures, while the scenario of climate neutrality will require a total investment of 252.9 billion HRK, i.e. additional investments of 149.4 billion HRK. Additional investments in non-energy sectors are estimated at 4.74 billion HRK. Total additional investments in all sectors to achieve the goals by 2030, with the aim of achieving climate neutrality in 2050, are estimated at 154.14 billion HRK.

The Republic of Croatia will have significant financial resources at its disposal, however, the investment needs significantly exceed the available resources. Therefore, inter-ministerial coordination and the use of innovative financial instruments will be necessary in order to attract private investment and achieve the greatest possible, multiplier effect in terms of emission reductions, given the limited financial resources available to us, since all sectors will have to contribute to reducing emissions in order for the Republic of Croatia to meet its share of the reduction in the EU goal of -55% by 2030.

Supporting the direction of the EU's climate policy, the development of a five-year Action Plan for the implementation of the Low-Carbon Strategy will take into account measures to achieve greater emission reductions by 2030.

APPENDIX I. – DESCRIPTION OF REFERENCE SCENARIO (NUR)

I.1. ENERGY PRODUCTION, CONSUMPTION, IMPORT AND EXPORT

Direct energy consumption

In the Reference Scenario (NUR), direct energy consumption by 2030 increases by a total of 5% and then decreases by 10% by 2050, monitored in relation to the level of direct energy consumption in 2018.

The structure of the consumed forms of energy is changing. The share of electricity, natural gas and hydrogen is expected to increase, while the share of solid and liquid fossil fuels is decreasing. The total share of fossil fuels is declining to 54.0% in 2030 and to 49.2% in 2050.

The share of direct energy consumption in industry will remain at about 17% throughout the monitored period. The share of turnover and the general consumption sector (households, services and agriculture) is expected to decrease.

Table I.1-1 and Table I.1-2 indicate the projections of direct energy consumption in the NUR scenario.

Table I.1-1: Direct energy consumption by fuels, NUR

kten	**2030**	**2040**	**2050**
Coal and coke	57.3	45.0	32.4
Non-renewable waste	10.6	10.0	8.1
Renewable sources	1505.2	1363.9	1110.2
Liquid fossil fuels	2596.2	2253.1	1653.1
Natural gas	1189.7	1269.8	1316.9
Electricity	1507.5	1612.0	1717.1
Heat	243.0	250.3	245.4
Hydrogen	0.004	0.2	15.9
Total	7109.7	6804.3	6098.9

Table I.1-2: Direct energy consumption by consumption branches, NUR

kten	**2030**	**2040**	**2050**
Industry	1186.7	1152.4	1077.8
Transport	2319.7	2189.6	1870.2
General consumption	3603.2	3462.2	3151.0
Households	2447.6	2267.6	1978.0
Services	950.0	1000.0	995.7
Agriculture	205.6	194.6	177.3
Total	7109.7	6804.3	6098.9

Total energy consumption

In the NUR scenario, total energy demands increase until 2030 and then decrease until 2050. Total consumption in 2030 is about 4% higher than today, while in 2050 the total energy demands are lower by 8%.

The share of solid and liquid fossil fuels and electricity in the structure of energy forms is declining, while the share of natural gas and hydrogen is increasing. The biggest change is expected on the side of RES, which share is increasing from 21.4% at the beginning of the period to 35.7% in 2030 and to 40.9% in 2050.

Table I.1-3 indicates the projections of total energy consumption in the NUR scenario.

Table I.1-3: Total energy consumption by fuels, NUR

kten	**2030**	**2040**	**2050**
Coal and coke	253.3	46.5	33.9
Liquid fossil fuels	3203.1	2797.5	2192.4
Natural gas	2446.8	2696.4	2621.2
Renewable sources	2936.3	3269.5	3351.9
Non-renewable waste	10.6	10.0	8.1
Electricity	334.6	130.6	27.1
Hydrogen	0.0	0.2	15.9
Total	9184.7	8950.7	8250.5

Renewable energy sources

In the NUR scenario, the use of energy from renewable sources as well as their diversification is increasing. By 2030, the use of renewable energy sources will increase by 55%, and by 2050 by 77%.

Table I.1-4 indicates the projections of renewable energy consumption in the NUR scenario.

Table I.1-4: Projections of renewable energy consumption in the NUR scenario

GWh	**2030**	**2040**	**2050**
Geothermal energy	208.5	374.1	446.3
Biofuels	257.9	304.5	305.9
Biogas	78.1	78.4	24.5
Solid biomass	1417.9	1284.6	1066.1
Solar energy	84.4	184.2	285.7
Wind energy	250.3	382.8	521.1
Hydropower	619.3	650.8	702.3
Total	2916.4	3259.4	3351.9

Electricity and heat production

In the NUR scenario, an increase in domestic production and a significant change in the structure of electricity production are expected. The share of renewable energy sources is increasing, while the share of thermal power plant production is decreasing (in general - thermal power plants, public boiler plants and industrial cogeneration). By the end of the monitored period, all the required amounts of electricity could be produced from domestic power plants, but exchange with neighbouring systems is possible (i.e. net import is equal to zero).

In the NUR scenario, the total power of power plants increases to 6.0 GW in 2030, and to 8.3 GW in 2050. The construction of new power plants in this scenario is the smallest among the considered scenarios, given that this scenario has the slowest increase in electricity consumption and the assumed rate of development of renewable energy sources is slower. On average, it is necessary to build about 200 MW of new power plants per year.

Table I.1-5 indicates the projections of electricity production in the NUR scenario.

Table I.1-5: Projections of electricity production in the NUR scenario

GWh	2030	2040	2050
Industrial cogeneration	332.7	310.6	262.1
Public cogeneration	3523.4	3577.1	3164.1
Thermal power plants	1426.8	2084.9	2639.0
Geothermal power plants	196.9	365.8	427.8
Solar power plants	670.8	1643.4	2564.6
Wind farms	3026.8	4452.4	6060.0
Hydropower plants	7201.9	7684.9	8167.8
Total	16379.5	20119.1	23285.4

Energy production and import

In the NUR scenario, the share of domestic energy production in total energy consumption decreases towards the end of the period due to a strong decline in production from domestic oil and gas deposits, as well as a slower increase in production from renewable energy sources.

Table I.1-6 indicates the projections of energy production and import in the NUR scenario.

Table I.1-6: Projections of energy production and import in the NUR scenario

GWh	2030	2040	2050
Domestic energy	5020.6	4692.2	3750.6
Imported energy	4164.2	4258.5	4445.6
Total	9184.9	8950.7	8196.3

I.2. INDUSTRY

The industry sector includes greenhouse gas emissions from fuel combustion and process emissions from the manufacturing industry, as well as emissions from the use of fluorinated greenhouse gases.

Manufacturing

The projections were made based on the expected development of individual branches of industry, which includes goals for 2050. The following key assumptions are included:

- Projections start from the state and projections of macroeconomic parameters and results of sectoral analyses.
- Industrial economic activity by industry branches was assessed based on sectoral analyses of the planned production of individual industry branches and projected macroeconomic indicators of gross added value by industry branches.
- Projections of emissions from energy consumption in manufacturing and construction are divided by sectors, according to the IPCC methodology. Process emissions from economic activities included in the industrial processes and product use sector according to the IPCC methodology are estimated based on detailed sectoral projections of cement, ammonia and nitric acid production and projected macroeconomic indicators of gross added value by other industry branches, annual growth rate of gross social product and population decline.
- Application of measures defined by strategic and planning sectoral documents included in the business policy of major manufacturers, which is conditioned by market requirements, laws and regulations and requirements for the application of best available techniques in production processes.
- Projections include assumptions that no new capacity will be installed in the industry and that production will reach maximum values by 2050.
- Process CO_2 emissions also come from NMVOC emissions which contribute to CO_2e emissions. Projections of NMVOC emissions for the period up to 2050 are calculated based on emissions from the last historical year and assuming a connection with population movements or economic growth or the continuation of the trend, depending on the categories.

Use of substitutes for ozone depleting substances

The NUR scenario includes the existing legal framework of the Republic of Croatia and the adopted EU legal framework in the field of the use of fluorinated greenhouse gases for the period until 2030. For the period after 2030, assumptions were used for the implementation of measures that would be achieved without climate change mitigation policies, based on population projections, number of vehicles and expert assessments based on the analysis of a group of countries with similar national characteristics.

Assumptions on limiting and reducing the use of fluorinated greenhouse gases, in accordance with the provisions of Regulation (EU) no. 517/2014 and Directive 2006/40/EC:

- Limiting the amount of fluorocarbons available on the market by 2030 to 21% of the total amount of fluorocarbons placed on the market during the reference period from 2009 to 2012.
- Limiting the possibility of retrofitting air-conditioning equipment designed to contain fluorinated greenhouse gases with a global warming potential above 150 in motor vehicles and prohibiting the filling of air-conditioning equipment with these gases.

I.3. TRANSPORT

The NUR scenario implies structural changes that are the result exclusively of existing energy efficiency and decarbonisation measures in the transport sector. In addition to the existing measures, the scenario

in question also takes into account progress in the context of the energy intensity of each individual technology.

The following assumptions are included:

- increase in the share of electric vehicles to 11% of the total number of personal vehicles in 2050, or 243,600 electric vehicles in 2050
- increase in the number of hybrid and plug-in hybrid vehicles to 14.6% of the total number of passenger cars by 2050, which would bring the number of hybrid and plug-in hybrid vehicles in 2050 to a total of 320,000
- increase in the number of vehicles that use hydrogen after 2030 to 1.4% of the total number of passenger cars, or to about 31,000 vehicles in 2050
- increase in the share of biofuels in petrol and diesel fuels to an average of 8% by 2050
- development of successful promotion of integrated urban transport
- development of intercity transport with emphasis on rail passenger and freight transport.

I.4. GENERAL CONSUMPTION

The following key assumptions are included in the projections in the general consumption sector:

- energy renovation of the building stock only to the extent that occurs without additional measures and policies
- there is no significant increase in the share of electricity in energy consumption for heat demands, and the dominant energy source for meeting heat demands is natural gas
- specific heat demands of the total housing stock in 2050 would be 93 kWh/m^2 of heated area, which is a consequence of 25% of newly built housing units and 4% of renovated at the end of the monitored period
- in 2050, households will be heated by 35% biomass (firewood and modern biomass), 14% by heat pumps (electricity), 10% by district heating and 41% by natural gas
- the area of the service sector is growing, and the structure of heating by energy products is similar to the structure of energy products in the household sector, while the specific energy needed for heating in 2050 is 80 kWh/m^2 of heated area.

I.5. AGRICULTURE

The model of emission projections was set using the following assumptions:

- Projections of the trend of activity input data for livestock and crop production were taken from the global FAO report "The future of food and agriculture - alternative routes until 2050", using the BAU (business as usual) scenario of the report.
- Use of mineral fertilizers obtained by extrapolation of the existing trend for the period from 2000 to 2016
- Implementation of the Rural Development Program of the Republic of Croatia for the period 2014-2020
- Minor changes in the livestock system and diet (changes in the fertilization system and genetic progress, increased digestibility and feed quality).

Based on the above policies and measures, the NUR scenario maintains the application of mineral fertilizers (nitrogen) to the soil at the level resulting from the trend of mineral fertilizer consumption in the period from 2000 to 2017, i.e. assumes that there will be no increase in mineral fertilizer consumption in accordance with estimated changes in crop and livestock production. For the purpose of detailed modelling of applied nitrogen, it is necessary to establish a system of real monitoring of mineral fertilizer consumption on farms, as well as estimates of the share of agricultural land under individual crops at

the state level as part of the development of soil maps and the study of the possibility of applying measures to reduce greenhouse gas emissions in the agricultural sector.

I.6. WASTE

The NUR scenario includes the existing legal framework of the Republic of Croatia and the adopted EU legal framework in the waste sector for the period until 2035. A five-year delay for the Republic of Croatia is included in the projections. For the period after 2040, the assumptions for the implementation of measures based on expert assessment were used, in accordance with the assumptions defined in the adopted planning documents.

The NUR scenario includes projections of emissions from the activities of disposal, biological treatment and incineration of solid waste and wastewater management. Projections were made based on expected development and future state of parameters for making projections - the amount of generated and disposed solid waste (municipal, production, sludge from wastewater treatment), the share of organic solid waste, the share of regenerated/incinerated methane and the amount of composted organic waste. Emission projections are based on projections of macroeconomic parameters from 2018 - annual growth rates of gross domestic product and population decline.

The following assumptions are included in the projection:

- Disposal of solid waste - reduction of the amount of generated and disposed solid waste due to the implementation of measures defined by sectoral legislation complied with EU legislation. On 4 July 2018, new EU rules came into force with legally binding goals for waste recycling and waste disposal reduction. The Republic of Croatia has been given the possibility of a five-year delay to meet these goals, because it is among the Member States that in 2013 recycled less than 20% of municipal waste or disposed of more than 60% in landfills. A five-year delay is included in the projections.
- Composting - a continuous increase in the amount of waste treated by composting due to the implementation of measures defined by sectoral legislation complied with EU legislation. The increase in the amount of waste to be composted depends on the decrease in the amount of disposed biodegradable waste and the share of biodegradable waste that will be treated by composting and digestion.
- Waste incineration - no more incineration of hospital waste is carried out without energy recovery.
- Wastewater management - continuous increase of the amount of treated wastewater of industry and reduction of the amount of treated wastewater of households and the number of inhabitants with an individual wastewater drainage system (septic tanks).

APPENDIX II. - DESCRIPTION OF GRADUAL TRANSITION SCENARIO OF LOW-CARBON STRATEGY (NU1)

II.1. ENERGY PRODUCTION, CONSUMPTION, IMPORT AND EXPORT

Direct energy consumption

In the Gradual Transition Scenario (NU1), direct energy consumption stagnates until 2030 and then decreases by 20% by 2050, as monitored in relation to the current level (2018) of direct energy consumption.

The structure of the consumed forms of energy is changing. The share of electricity and hydrogen is expected to increase, while the share of solid and liquid fossil fuels is decreasing. Natural gas consumption remains roughly the same until 2030 and then declines by 15% by 2050. The total share of fossil fuels is declining to 53.2% in 2030 and to 41.0% in 2050.

The share of direct energy consumption in industry will remain at about 17% by 2030 and then increase to 19.8% in 2050. The share of turnover is expected to decrease, while the share of total consumption in the general consumption sector (households, services and agriculture) remains approximately constant.

Table II.1-1 and Table II 1-2 indicate the projections of direct energy consumption in the NU1 scenario.

Table II.1-1: Direct energy consumption by fuels, NU1

kten	**2030**	**2040**	**2050**
Coal and coke	55.4	40.7	26.1
Non-renewable waste	10.6	10.0	8.1
Renewable sources	1448.0	1297.0	1030.9
Liquid fossil fuels	2493.0	2082.4	1266.8
Natural gas	1097.4	1020.1	917.5
Electricity	1515.6	1660.0	1926.3
Heat	232.7	223.0	197.1
Hydrogen	0.004	0.2	15.9
Total	6852.8	6333.3	5388.7

Table II.1-2: Direct energy consumption by branches, NU1

kten	2030	2040	2050
Industry	1183.9	1144.3	1065.5
Transport	2212.8	2054.7	1634.7
General consumption	3456.1	3134.3	2688.5
Households	2314.9	1995.6	1632.6
Services	935.7	944.2	878.7
Agriculture	205.5	194.5	177.2
Total	6852.8	6333.3	5388.7

Total energy consumption

In the NU1 scenario, total energy demands decrease throughout the period. Total consumption in 2030 is 1% lower than today, and in 2050 it is 17% lower.

The share of natural gas, solid and liquid fuels and electricity in the structure of energy forms is declining. The biggest change is expected on the side of RES, which share increases to 32.0% in 2030 and to 46.3% in 2050.

Table II.1-3 indicates the projections of total energy consumption in the NU1 scenario.

Table II.1-3: Total energy consumption by fuels, NU1

kten	2030	2040	2050
Coal and coke	214.5	42.2	27.7
Liquid fossil fuels	3092.2	2609.1	1788.0
Natural gas	2313.3	2229.2	2124.0
Renewable sources	2817.6	3272.2	3426.0
Non-renewable waste	10.6	10.0	8.1
Electricity	335.4	160.2	2.1
Hydrogen	0.0	0.2	15.9
Total	8783.7	8323.2	7391.7

Renewable energy sources

In the NU1 scenario, a strong increase in the use of energy from renewable sources and diversification of used energy sources is expected. By 2030, the use of RES will increase by 49%, and by 2050 by 81%.

Table II.1-4 indicates the projections of renewable energy consumption in the NU1 scenario.

Table II.1-4: Projections of renewable energy consumption in the NU1 scenario

GWh	2030.	2040.	2050.
Geothermal energy	153.0	374.4	442.6
Biofuels	248.3	277.3	193.7
Biogas	69.5	77.6	34.5
Solid biomass	1292.6	1136.3	957.4
Solar energy	119.7	265.5	413.2
Wind energy	305.1	476.7	675.7
Hydropower	629.3	662.3	708.9
Total	2817.6	3270.2	3426.0

Electricity and heat production

In the NU1 scenario, an increase in domestic production and a significant change in the structure of electricity production are expected. The share of renewable energy sources is increasing, while the share of thermal power plant production is decreasing (in general - thermal power plants, public boiler plants and industrial cogeneration). By the end of the monitored period, all the required amounts of electricity could be produced from domestic power plants, but exchange with neighbouring systems is possible (i.e. net import is equal to zero).

In the NU1 scenario, the total power of power plants increases to 6.57 GW in 2030, and to 10.3 GW in 2050. On average, it is necessary to build about 260 MW of new power plants per year.

In NU1, by the end of the period, it is assumed that the Krško NPP and the existing units at the Plomin location will be decommissioned. There is no construction of new coal-fired thermal power plants.

Table II.1-5 indicates the projections of electricity production in the NU1 scenario.

Table II.1-5: Projections of electricity production in the NU1 scenario

GWh	2030	2040	2050
Industrial cogeneration	320,3	280,4	239,8
Public cogeneration	3508,0	3971,5	3199,7
Thermal power plants	799,5	160,3	1951,9
Geothermal power plants	128,8	365,8	427,8
Solar power plants	1013,3	2374,6	3624,4
Wind farms	3548,8	5544,6	7858,9
Hydropower plants	7319,2	7702,5	8244,3
Total	16637,9	20399,6	25546,7

Energy production and import

In the NU1 scenario, the share of domestic energy production in total energy consumption continues to increase towards the end of the period, which is explained by a decrease in total energy demands: due

to energy efficiency measures - renovation of buildings and switching to other forms of energy (e.g. electricity in transport). At the same time, RES production is increasing, and despite the decline in fossil fuel production, own supply is increasing to 55.8% in 2030, to drop to 51.7% in 2050 thereafter.

Table II.1-6 indicates the projections of energy production and import in the NU1 scenario.

Table II.1-6: Projections of energy production and import in the NU1 scenario

GWh	2030	2040	2050
Domestic energy	4922.0	4700.6	3824.7
Imported energy	3861.6	3622.6	3566.9
Total	8783.7	8323.2	7391.7

II.2. INDUSTRY

The scenario includes the application of cost-effective measures to reduce greenhouse gas emissions from energy consumption by industry and process emissions in cement production, and to reduce emissions of volatile organic compounds, controlled substances and fluorinated greenhouse gases.

Processing industry

Measures to reduce greenhouse gas emissions from energy consumption in industry include:

- increase energy efficiency
- replacement of energy sources in industrial cogeneration / district heating plants
- use of biofuels in off-road vehicles.

Process measures to reduce greenhouse gas emissions from industrial processes:

- gradual reduction of clinker share in cement production (in 2030 the share amounts to 65%, and in 2050 to 50%).

Use of substitutes for ozone depleting substances

The NU1 scenario includes a more intensive reduction of fluorinated greenhouse gases available on the market after 2030, compared to the NUR scenario, in accordance with the expert assessment based on the continuation of the declining trend of fluorinated greenhouse gases. The NU1 scenario includes assumptions about the number of vehicles, which is related to the reduction of fluorinated greenhouse gas emissions from mobile air conditioning systems. Limiting the possibility of retrofitting air conditioning equipment designed to contain fluorinated greenhouse gases with a global warming potential above 150 in motor vehicles is based on expert assessment, according to an analysis of a group of countries with similar national characteristics.

II.3. TRANSPORT

In the transport sector, the following assumptions and measures are included in the NU1 scenario:

- increase in the share of electric vehicles to 35% of the total number of cars in 2050, i.e. 762,700 electric vehicles in 2050
- increase in the number of hybrid and plug-in hybrid vehicles to 20% (6% hybrid and 14% plug-in hybrid) of the total number of passenger cars by 2050, bringing the number of hybrid and

plug-in hybrid vehicles in 2030 to about 70,000, and in 2050 the number of vehicles for both categories would be a total of 449,000 vehicles
- increase in the number of vehicles that use hydrogen after 2030 to 1.4% of the total number of passenger cars, or to about 31,000 vehicles in 2050
- increase in share of biofuels in petrol and diesel fuels to an average of 12% by 2050
- popularization of the integrated and intermodal with an emphasis on development of rail freight, (growth to about 25% in 2050), with the successive introduction of electric locomotives instead of diesel
- in maritime transport, it is assumed that in 2050 the share of biofuels will amount to 20%, and of LNG to 5%.

II.4. GENERAL CONSUMPTION SECTOR

The following measures are included in the NU1 scenario for achieving the goals:

- the most significant contribution to the reduction of energy consumption is given by the energy renovation of buildings - renovation of the existing building stock, suitable for renovation, at an annual rate of 1.6%.
- in the household sector, the renovation of about 10,000 housing units per year is planned
- an increase in the share of electricity for thermal purposes is strongly present
- by 2050, 36% of the building stock are newly built housing units, and 21% of housing units have improved thermal insulation compared to 2016, which results in a specific consumption of 67 kWh / m2 of heated area
- the structure of energy sources for heating in households in 2050 is 43% of biomass (with 27% being modern biomass and the rest firewood), 19% heat pumps, 10% of district heating and 29% of natural gas
- heat needs in the service sector by 2050 are reduced to 55 kWh / m^2 of heated area.

II.5. AGRICULTURE

Positive impact of applying measures on the total greenhouse gas emissions in the agricultural sector is reflected through a direct reduction in emissions of methane and nitrogen compounds. Measures included in the formation of the NU1 scenario of agriculture in relation to the NUR scenario:

- changes in the diet of cattle and pigs and the composition of animal feed
- anaerobic digestion (of silage and renewable lignocellulosic raw materials, organic by-products of the food industry and slaughterhouses, biodegradable solid waste fractions and microbial biomass) and biogas production for production of electricity and heat and fuel for internal combustion engines
- improve facilities or dwellings as well as manure management system
- improve fertilizer application
- construction of hydromelioration projects
- encourage the development of precision agriculture based on developed GIS and GPS technologies
- introduction of new varieties and species.

To assess the potential reduction of total emissions by increasing organic carbon in the soil by applying an additional set of measures, it is necessary to conduct national surveys to define the actual potentials to increase carbon sinks in agricultural soils in the Republic of Croatia, especially the application of reduced tillage systems, as well as continue to explore the potential for application depending on soil type. Measures that have the potential to increase carbon sequestration:

- Improvement and change of tillage system (reduced tillage)
- Expansion of crop rotation with a higher share of leguminous plants

- Intensifying crop rotation using intermediate crops
- Improving the application of organic fertilizers
- Green manure
- Agroforestry.

II.6. WASTE

The NU1 scenario is the same as the NUR scenario as no additional emission reduction measures have been identified. A comparative analysis of a group of countries with similar national characteristics found that national legislation, which is in line with EU legislation, prescribes measures that all Member States must implement by a certain deadline and considers them within the measures scenario (corresponding to the NUR scenario).

APPENDIX III. - DESCRIPTION OF THE LOW-CARBON SCENARIO OF STRONG TRANSITION (NU2)

III.1. ENERGY PRODUCTION, CONSUMPTION, IMPORT AND EXPORT

Direct energy consumption

In the Strong Transition Scenario (NU2), direct energy consumption will decrease by a total of 4% by 2030 and then by 33% by 2050, compared to the current level (2018) of direct energy consumption.

The structure of the consumed forms of energy will change. The share of electricity and hydrogen is expected to increase, while the share of natural gas and solid and liquid fossil fuels will decrease. The total share of fossil fuels will decline to 53.8% in 2030 and to 32.0% in 2050.

Direct energy consumption in all branches (industry, transport, general consumption) decreases throughout the observed period.

Table III.1-1 and Table III.1-2 indicate the projections of direct energy consumption in the NU2 scenario.

Table III.1-1: Direct energy consumption by fuels, NU2

kten	**2030**	**2040**	**2050**
Coal and coke	51.8	34.2	17.8
Non-renewable waste	10.6	10.0	8.1
Renewable sources	1232.4	940.2	775.7
Liquid fossil fuels	2444.1	2006.2	887.5
Natural gas	1007.6	793.7	542.3
Electricity	1547.7	1724.7	2129.9
Heat	214.1	182.9	136.9
Hydrogen	0.005	0.3	30.2
Total	6508.3	5692.2	4528.3

Table III.1-2: Direct energy consumption by branches, NU2

kten	**2030**	**2040**	**2050**
Industry	1165.7	1110.0	1017.1
Transport	2178.9	1998.6	1416.8
General consumption	3163.6	2583.6	2094.4
Households	2038.2	1504.0	1153.2
Services	919.9	885.1	764.0
Agriculture	205.5	194.5	177.2
Total	6508.3	5692.2	4528.3

Total energy consumption

In the NU2 scenario, total energy needs decline throughout the period. Total consumption in 2030 is 5% lower than today, and in 2050 it is lower by 26%.

The share of natural gas, solid and liquid fuels and electricity in the structure of energy forms will decrease. The biggest change is expected on the side of RES, whose share will grow to 32.0% in 2030 and to 56.2% in 2050.

Table III.1-3 indicates the projections of total energy consumption in the NU2 scenario.

Table III.1-3: Total energy consumption by fuels, NU2

kten	2030	2040	2050
Coal and coke	208.2	35.7	19.3
Liquid fossil fuels	3033.8	2499.3	1340.2
Natural gas	3168.9	1774.2	1455.4
Renewable sources	2693.2	3043.0	3663.9
Non-renewable waste	10.6	10.0	8.1
Electricity	292.7	157.9	2.2
Hydrogen	0.0	0.3	30.2
Total	8407.5	7520.4	6519.2

Renewable energy sources

In the NU2 scenario, a strong increase in the use of energy from renewable sources and diversification of used energy sources is expected. By 2030, the use of RES will increase by 42%, and by 2050 by 93%.

Table III.1-4 indicates the projections of renewable energy sources consumption in the NU2 scenario.

Table III.1-4: Projections of renewable energy sources consumption in the NU2 scenario

GWh	2030	2040	2050
Geothermal energy	152.3	373.5	441.2
Biofuels	132.7	269.6	109.8
Biogas	67.9	76.7	123.5
Solid biomass	1083.1	677.0	656.0
Solar energy	157.4	368.0	584.8
Wind energy	327.4	617.7	908.3
Hydropower	628.3	565.7	840.3
Total	2693.2	3039.1	3663.9

Electricity and heat production

In the NU2 scenario, an increase in domestic production and a significant change in the structure of electricity production are expected. The share of renewable energy sources will increase, while the share

of thermal power plant production will decrease (in general - thermal power plants, public heating plants and industrial cogeneration). By the end of the observed period, all the required amounts of electricity could be produced from domestic power plants, but exchange with neighbouring systems is possible (i.e. net imports are equal to zero).

In the NU2 scenario, the total power of power plants increases to 7.1 GW in 2030, and to 12.9 GW in 2050. On average, it is necessary to build about 350 MW of new power plants per year. The main reason for the significant increase in capacity is the construction of a large number of RES, with an average of 110 MW of new wind farms per year and 100 MW of solar power plants per year over a thirty-year period.

In NU1, by the end of the period, it is assumed that NPP Krško and the existing units at the Plomin location will be decommissioned. There is no construction of new coal-fired thermal power plants.

Table III.1-5 indicates the projections of electricity production in the NU2 scenario.

Table III.1-5: Projections of electricity production in the NU2 scenario

GWh	2030	2040	2050
Industrial cogeneration	320.3	280.4	239.8
Public cogeneration	3316.4	2394.0	1636.8
Thermal power plants	719.8	0.0	1764.3
Geothermal power plants	128.8	365.8	427.8
Solar power plants	1371.0	3316.0	5133.1
Wind farms	4331.6	7183.7	10563.2
Hydropower plants	7307.2	7637.7	9772.7
Total	17495.2	21177.6	29537.8

Energy production and import

In the NU2 scenario, the share of domestic energy production in total energy consumption continues to grow towards the end of the period, which is explained by a decrease in total energy needs: due to strong energy efficiency measures - renovation of buildings and switching to other forms of energy (e.g. electricity in transport). At the same time, RES production will increase, and despite declining fossil fuel production, own supply will grow to 56.8% in 2030 and to 62.0% in 2050.

Table III.1-6 indicates the projections of energy production and import in the NU2 scenario.

Table III.1-6: Projections of energy production and import in the NU2 scenario

GWh	2030	2040	2050
Domestic energy	4797.6	4471.4	4039.0
Imported energy	3609.9	3049.1	2480.2
Total	8407.5	7520.4	6519.2

III.2. INDUSTRY

Process industry

The scenario includes more intensive application of process measures related to the gradual reduction of the share of clinker in cement production (30% in 2050) and measures of capture and storage of CO2 in cement production plants from 2040 as well as reduction of emissions of controlled substances and fluorinated greenhouse gases throughout the observed period until 2050. Additionally, increased use of biomass in industrial heating plants and cogeneration is envisaged.

Use of substitutes for ozone depleting substances

The NU2 scenario includes a more intensive reduction in fluorinated greenhouse gases available on the market after 2030, compared to the NU1 scenario. The NU2 scenario includes assumptions about the number of vehicles, which is related to a more intensive reduction of fluorinated greenhouse gas emissions from mobile air conditioning systems.

III.3. TRANSPORT

The transport sector in the NU2 scenario is modelled with the basic assumption of a strong increase in the share of electric vehicles.

The following assumptions and measures are included in scenario NU2:

- increase in the share of electric cars to 61% of the total number of cars in 2050, 1.23 million electric cars in 2050,
- an increase in the number of hybrid and plug-in hybrid vehicles to 14.7% (2.8% hybrid and 11.9% plug-in hybrid) of the total number of passenger cars by 2050, bringing the number of hybrid and plug-in hybrids vehicles in 2030 amounted to about 69,800, and in 2050 a total of 297,000 vehicles.
- increase in the number of vehicles using hydrogen after 2030 to 2.9% of the total number of passenger cars, or to about 59,600 vehicles in 2050
- increase in the share of biofuels in petrol and diesel fuels to an average of 27% by 2050
- higher applicability of intermodality - increase in the share of freight traffic achieved by rail (electric locomotives) to about 30% in 2050
- in maritime transport, it is assumed that in 2050 the share of biofuels will amount to 20%, LNG 10%.

III.4. GENERAL CONSUMPTION SECTOR

In the NU2 scenario, the following measures are required to achieve the objectives:

- the most significant contribution to the reduction of energy consumption is given by energy renovation of buildings - renovation of the existing building stock, suitable for renovation, at an annual rate of 3%, which means that by 2050 the entire building stock will become low energy. Meanwhile, in December 2020, the Long-Term Strategy for the Renovation of the National Building Fund to 2050 was adopted, which was raised to 4%, which is a fulfilment that depends on securing financial resources.
- in the household sector, the renovation of about 20,000 housing units per year is planned.
- an increase in the share of electricity for thermal purposes is strongly present
- by 2050, half of the housing stock will be newly built housing units compared to today, and in the second half all housing units will have improved thermal insulation, resulting in the thermal needs of the total housing stock of 34 kWh / m2 of heated area
- in 2050, households will be heated by 25% modern biomass, 45% heat pumps, 10% district heating and 20% natural gas, 30% of hot water preparation is by solar collectors

- the area of the service sector is growing, heat demand will be reduced to 30 kWh / m2 by 2050, the structure of heating and preparation of domestic hot water is similar to that for households.

III.5. AGRICULTURE

Additional significant reduction of greenhouse gas emissions can be achieved with changes in the company's eating habits, i.e. by applying additional measures in relation to the NUR and NU1 scenarios:

- Change in nutrition - changing the way people eat in terms of greater consumption of foods of plant origin.

III.6. WASTE

The NU2 scenario is the same as the NUR scenario as no additional emission reduction measures have been identified. A comparative analysis of a group of countries with similar national characteristics found that national legislation, which is in line with EU legislation, prescribes measures that all Member States must implement by a certain deadline and considers them within the measures scenario (corresponding to the NUR scenario).

APPENDIX IV. - RESULTS OF SENSITIVITY ANALYSIS

The EU Governance Regulation recommends that national scenarios should use, as far as possible and justified, the assumptions and baselines used for joint EU projections.

In June 2018, the EC drafted the document Recommended harmonized parameters for purposes of drafting national projections, integrated plans and long-term strategies. Recommended parameters include projections of demographic development, GDP rate, gross value added of individual industries, fuel price projections and emission units. In case of deviation, i.e. non-use of the recommended parameters, it is necessary to make a sensitivity analysis and determine changes in greenhouse gas emissions.

Key differences in the baseline data of the national NUR, NU1 and NU2 scenarios and the baseline data used by the EU in the common scenarios are population projections and GDP projections. demographic and economic development.

In all three observed scenarios (NUR, NU1, NU2) the demographic and economic parameters are the same (described in Chapter 3.3.1).

GDP rate

In the analysed scenarios, GDP growth is assumed to be at an average of 2.0% by 2050, which is a nominal increase of 93.4% compared to 2016.

Recommended GDP growth rates in the document Recommended harmonized parameters for development of national projections, integrated plans and long-term strategies assume GDP growth by 2050, on average 1.7% by 2050, which is a nominal increase of 77.3% compared to 2016.

With the use of recommended GDP growth rates, greenhouse gas emissions in 2030 are lower by about 1.2% compared to the NUR, NU1 and NU2 scenarios. Greenhouse gas emissions in 2050 are lower by 1.2%, 1.3% and 0.7% compared to the NUR, NU1 and NU2 scenarios, assuming the same carbon intensity of the economy. However, the implementation of measures to reduce emissions reduces and, in the long run, breaks the link between GDP and emissions. Thus, GDP growth contributes to reducing emissions when it comes through investments in low-carbon technologies, industry and services.

Greenhouse gas emission in 2050 is lower by 1.2%, 1.3% and 0.7% compared to the NUR, NU1 and NU2 scenarios, assuming the same carbon intensity of the economy. However, the implementation of measures to reduce emissions decreases and, in the long run, breaks the link between GDP and emissions. Thus, GDP growth contributes to reducing emissions when it comes through investments in low-carbon technologies, industry and services.

Population trends

NUR, NU1 and NU2 scenarios were made with the assumption that the number of inhabitants in the Republic of Croatia in 2030 is 3,755,419, and in 2050 3,295,443. Recommended parameters of demographic development projections from the document Recommended harmonized parameters for the needs of national projections, integrated plans and long-term strategies give 8.7% more inhabitants in 2030, and 16% more inhabitants in 2050, compared to the assumed number of inhabitants in NUR, NU1 and NU2 scenarios.

Low-carbon scenarios separate GDP from greenhouse gas emissions, and thus emissions per capita decrease. In the NU1 scenario in 2030 it is 5.6 t CO_2e / dwelling, and in 2050 4.2 t CO_2e / dwelling and 5.4 t CO_2e / dwelling in 2030 in the NU2 scenario, or 2.6 t CO_2e / dwelling in 2050. Variations in demographic trends have less and less impact on emissions and cannot significantly change the set trends.

Using the recommended parameters of demographic development from the document Recommended harmonized parameters for the needs of national projections, integrated plans and long-term strategies, greenhouse gas emissions in 2030 are higher by about 4% compared to NU1 and NU2 scenarios, and in 2050 it is higher by 4.2% and by 2.6% higher, respectively, compared to the NU1 and NU2 scenarios.

APPENDIX V. - MEASURES BASED ON WHICH THE SCENARIOS WERE DEVELOPED

REFERENCE	MEASURE NAME AND DESCRIPTION	
CROSS-SECTORAL MEASURES		
MCC-1	Committee for cross-sectoral coordination of policies and measures for mitigation and adaptation to climate change	The Committee, appointed by the Government of the Republic of Croatia, was established in 2014 and is responsible for monitoring and evaluating the implementation and planning of policies and measures for climate change mitigation and adaptation in the Republic of Croatia. Officials of the competent state administration bodies were appointed to the Committee, but other representatives of public authorities, professional organizations and representatives of state-owned companies may also be invited to the sessions, as required.
MCC-2	Strengthening regional energy and climate agencies	Regional energy agencies do not currently operate in the entire territory of the Republic of Croatia. The aim of this measure is to strengthen regional energy agencies, transform existing energy agencies into energy and climate agencies and expand their field.
MCC-3	Promotion of the use of innovative information and communication technologies (ICT) to reduce greenhouse gas emissions	Innovative information and communication technologies have an increasingly important role in reducing greenhouse gas emissions and increasing energy efficiency. Intensifying their use in public administration, services and manufacturing processes, will boost productivity and work efficiency and at the same time will reduce energy consumption and consequent greenhouse gas emissions. The measure is expected to intensify the use of innovative ICT and monitoring of actual energy savings and reductions of greenhouse gas emissions.
MCC-4	EU Emissions Trading System	Through the equitable distribution of emission allowances, reduction commitments were distributed to system participants from all Member States with the aim of contributing to emission reductions at EU level by at least 43% until 2030 compared to 2005 levels.
MCC-5	The CO_2 emission tax for the non-ETS stationary sources	The Regulation on unit charges, corrective coefficients and detailed criteria and benchmarks for determining the charge for emissions of carbon dioxide into the environment (Official Gazette, No. 73/07, 48/09, 2/18) stipulates the obligation to pay the CO_2 emission tax for all stationary sources emitting more than 450 tons of CO_2 per year. The obligated parties investing in energy efficiency, renewable energy and other measures to reduce CO_2 emissions and other GHG emissions pay a lower tax. The Environmental Protection and Energy Efficiency Fund is authorized to calculate and charge the tax. From 2013 onwards, the obligation to pay the CO_2 emission tax has applied only to non-ETS sources.

REFERENCE	MEASURE NAME AND DESCRIPTION	
MCC-6	Covenant of Mayors for Climate and Energy in the Republic of Croatia	The signatories of the Covenant support a common vision for 2050: accelerating the decarbonisation of their territories, strengthening the capacity to adapt to the inevitable impact of climate change, and providing citizens with access to safe, sustainable and affordable energy. The covenant covers 82 cities and municipalities, i.e. over 2 million inhabitants in the Republic of Croatia.
MCC-7	Charter for Buildings Decarbonisation by 2050	Charter on cooperation for the decarbonisation of buildings by 2050 is initiated by the Ministry of Physical Planning, Construction and State Assets, which supports the EU vision of decarbonisation of buildings by 2050. The charter was launched for better interdepartmental communication and cooperation between government and the real sector. The goal is to create a wide network of connected experts through workshops and open dialogue of partners who are ready for a joint dialogue and contribution to the decarbonisation of the building fund by 2050. Open dialogues of partners bring together representatives of state and local government, academia and the professional public, construction and energy sectors and related industries in thematic workshops organized by the Ministry of Construction and Physical Planning. The contents of the Charter relate to the achievement of energy and climate goals at national and EU level through the decarbonisation of the building stock, renovation of buildings and construction of nearly-zero energy buildings, aware of the importance of further reducing greenhouse gas emissions, increasing the share of renewable energy sources, improving energy security, and introducing innovations and smart technologies that enable buildings to support the overall decarbonisation of the economy. The signing of the charter encourages continuous cooperation in the development of the Long-Term Strategy for the Reconstruction of the National Building Fund and the transition to the standard of construction of near-zero energy buildings (nZEB). The signatories of the Charter provide support and promote the decarbonisation of buildings in their further activities, wherever possible.
MCC-8	Creation of Platform for Carbon Capture, Use and Storage	Carbon capture and storage technology for large emission sources is not yet commercially available. According to Directive 2009/31/EC on geological storage of carbon dioxide, i.e. Article 36 of Directive 2010/75/EU on industrial emissions, for power plants with a capacity of more than 300 MW which received a building permit after the entry into force of Directive 2009/31/EC on geological storage of carbon dioxide, it is necessary to assess whether the following conditions are met: a) availability of a suitable storage site, b) technical and economic feasibility of transport facilities and c) technical and economic feasibility of upgrading the CO_2 capture and collection facility. If these conditions are met, the competent authority must provide adequate space at the installation site for equipment to capture and compress the extracted CO_2. Legislatively, this is covered by the Hydrocarbon Exploration and Exploitation Act (Official Gazette, No. 52/2018 and 52/2019), which enables the storage of CO_2 in the territory of the Republic of Croatia. This method needs to be further developed and the potentials and possibilities for this technology need to be considered at the state level. In accordance with the above, it is planned to prepare a study of storage capacity assessment, but also to prepare a National Feasibility Study with an action plan for preparatory activities for CCS projects. This study will cover the phases of capture

REFERENCE	MEASURE NAME AND DESCRIPTION	
		at emission sources, transport, injection and storage of CO_2, and the connection of the CO_2 transport system with other EU countries. Activities include: – conducting research on the potential for geological storage of CO_2 in the Republic of Croatia, – preparation / supplementation of a study on the assessment of storage capacities available in the territory of the Republic of Croatia, – implementation of geological CO_2 storage projects in the Republic of Croatia in accordance with the expressed potentials.
MCC-9	Improving sustainability of urban areas	The development of new national programs for the development of green infrastructure in urban areas and the Program for the development of circular management of space and buildings, which achieve environmental, economic and social benefits of sustainable development. The program for the development of green infrastructure in urban areas elaborates goals and measures for the development of green infrastructure which, among other things, increase the energy efficiency of buildings and construction areas, develop green infrastructure in buildings, urban transformation and urban rehabilitation and reduce temperatures in areas of thermal islands in urban areas. areas. The program for the development of circular space management of buildings elaborates goals and measures for circular space management and buildings which, among other things, encourage circular measures in planning new buildings, reusing abandoned and / or neglected and extending the durability of existing spaces and buildings, reducing construction waste and increasing energy efficiency of buildings. The aim of this measure is to encourage cities and municipalities to base revitalization and development projects on new urban areas on the principles of sustainability. The first step in this is the development of urban development plans, in which, based on the assessment of sustainability indicators, development projects will be defined that will improve these indicators. The measure will enable the improvement of sustainable development by directly linking strategic and spatial planning documents and by introducing performance measurement of planned and implemented projects. Measure reference in the Long-Term Reconstruction Strategy: MS-9
MCC-10	Establishment of the Programme for calculation and reduction of carbon footprint of business entities	The following activities will be carried out within the measure: – improvement of the national model for calculating the carbon footprint of business entities with an integrated database of national greenhouse gas emission factors, – establishment and implementation of a voluntary program for the calculation and reduction of the carbon footprint of business entities from 2021 – monitoring and analysis of the achieved reduction of the carbon footprint of business entities; the adoption of a bylaw will be considered, which will establish the obligation to calculate the carbon

REFERENCE	MEASURE NAME AND DESCRIPTION	
		footprint and the development of an action plan for the reduction of the carbon footprint of business entities.
MCC-11	Establishment of the Platform for Circular Economy	It is necessary to develop a systematic approach in all value chains related to the Croatian economy related to the measures listed in the Action Plan for the Circular Economy, based on which the EC integrates the principles of the circular economy in plastic production and consumption, water management, food systems and special waste management streams. It is necessary to establish a cross-sectoral thematic working group that will identify stakeholders in the circular economy (focus on industry and suppliers of raw materials, energy and packaging) and draw up a national action plan for the transition to the circular economy by adapting the legislative framework. The inclusion of the representatives of the Republic of Croatia in the Stakeholder Platform for the European Circular Economy enables direct access to innovations and best practices as well as cooperation in them.
MCC-12	Establishment of the Platform for Bioeconomy	In the context of bioeconomy development, it is necessary to connect three key aspects: development of new technologies and processes; market development and competitiveness of sectors based on the principles of the circular economy and the political will for cooperation between policy and stakeholders. This should ensure the transformation of existing "traditional" stakeholders of the bioeconomy (farmers, family farms, food processing, forestry, wood processing, pharmaceutical, chemical industry…) into new, modern stakeholders in low-carbon economy and sustainable development while supporting the positive impact on ecosystems, climate and carbon cycle. An in-depth analysis of stakeholders (sectors) is necessary for the transition to a bioeconomy, and that their economic activity contributes to the achievement of development goals based on low levels of emissions of carbon dioxide and other greenhouse gases. In parallel, the adjustment of the involved economic entities is needed for the use of funds from the announced EU funds intended for the transition to the bioeconomy.
MCC-13	Establishment of the Platform for Hydrogen Technologies	The role of hydrogen in the energy and transport systems of the future is expected to be more significant, even more so as the targets for reducing greenhouse gas emissions will be more ambitious. Therefore, it is necessary to identify opportunities related to the use of hydrogen in a timely manner, consider its application in the next decade and explore the possibilities of financially stimulating the production and consumption of hydrogen. To this end, a hydrogen technology platform will be established to connect national stakeholders relevant to hydrogen technology research and application, monitor the development of hydrogen technologies at EU and international level, and serve as a link between national, EU and international levels.
MCC-14	Energy efficiency obligation system for suppliers	The obligators of the system of energy efficiency obligations are energy suppliers. The goal is to achieve a reduction in energy consumption by end consumers.
MCC-15		The National System for monitoring, measurement and verification of savings is established on the basis of the Energy Efficiency Act (Official Gazette, No. 127/14, 116/18, 25/20) and the Ordinance on the System for Monitoring, Measuring and Verifying Energy Savings (Official Gazette, No. 33/20). This system is extremely

REFERENCE	MEASURE NAME AND DESCRIPTION	
	Integrated information system for monitoring energy efficiency	important because it monitors energy savings and the resulting reduction in greenhouse gases and the system data are used for reporting. In the next period, it is necessary to maintain and improve the functionality of the system, connect it to other systems (EMIS), and inform and educate obligated parties about the correct data entry required to calculate and verify energy savings.
MCC-16	Green public procurement	In 2015, the Government of the Republic of Croatia adopted the First National Action Plan for Green Public Procurement for the period from 2015 to 2017 with a view to 2020, and green public procurement was accepted as a measure in the 4th National Energy Efficiency Action Plan, which aims that until 2020 green public procurement criteria be applied in 50% of conducted public procurement procedures. Green public procurement will encourage the procurement of innovative low-carbon products and services, which will further encourage their entry into the market, and the public sector will serve as a good example. The strategic goal in 2030 is to have 75% of the implemented public procurement procedures for priority product groups with changed green public procurement criteria. Measure reference in the Long-Term Reconstruction Strategy: ENU-9
MCC-17	Determining the starting point, national goals, indicators for monitoring the achievement and establishing a system for monitoring the achievement of the set goals of research, innovation and competitiveness	Elaboration of goals and monitoring system and establishment of a system for monitoring achievements in the field of research and development, innovation and competitiveness related to the Energy Union; defining key technologies for Low-Carbon transition.
MCC-18	Co-financing of industrial research and experimental development projects aligned with the National Development Strategy	The measure encourages research and development of products and services relevant to low-carbon development, by co-financing research projects within priority topics.
MCC-19	Supporting Low-Carbon entrepreneurship development	The measure encourages the development of entrepreneurship in the field of low-carbon products and services, by co-financing entrepreneurial activities in this area.
MCC-20	Supporting knowledge and technology transfer from	The measure encourages the development of established and functional technology transfer offices and science and technology parks with the aim of transferring knowledge and developing technologies that will contribute to the development of a low-carbon economy.

REFERENCE	MEASURE NAME AND DESCRIPTION	
	science to economy with focus on Low-Carbon technologies	
MCC-21	Supporting further work of excellence centres active in the field of natural, technical, biotechnical and biomedical sciences	The measure encourages the further work of established and centers of excellence, whose work was positively assessed in the periodic evaluation process with the aim of further development of the low-carbon economy.
MCC-22	Capacity building for stimulating research and innovation and increasing competitiveness in the Low-Carbon economy	The capacities of the institutions involved in encouraging and monitoring research, innovation and competitiveness in the low-carbon economy will be built.
MCC-23	Strengthening the capacity of county institutes for physical planning and the Institute for Physical Planning of the City of Zagreb as regional centres for sustainable development and climate activities within the scope of their work	The County Institutes for Physical Planning and the Institute for Physical Planning of the City of Zagreb, whose main task is the development, i.e. coordination of the development and monitoring of the implementation of spatial plans and the preparation of reports on the state of space, may be regional centres for sustainable development and climatic activities. Spatial and urban plans are one of the most important instruments for the implementation of climate policies and have the force and legal nature of bylaws. The principle of an integrated approach to spatial planning only ensures the optimal synergy effect of sectoral policies and low-carbon development measures in order to reduce emissions. The planning paradigm aimed at low-carbon or carbon-free development and decarbonization is the starting point for a new generation of spatial plans.
MCC-24	Modification of the regulatory framework in the field of spatial planning	The Law on Physical Planning should be amended and supplemented with the starting points and goals of low-carbon development. Spatial plans bring together all sectoral policies and measures, from the energy sector, transport, agriculture, economy, LULUCF, etc.
ENERGY		
MEN-1	Promoting nZEB construction and renovation standards	After 31 December 2018 all public buildings in the Republic of Croatia in which they reside or are owned by public bodies must be constructed according to the nZEB standard, and the obligation for all other newly constructed buildings occurs after 31 December 2020. These legal provisions ensure that all newly constructed buildings from 2021 onwards are according to the nZEB standard. However, in order to ensure the correct application of these directives, but also to encourage energy renovation of buildings according to the nZEB

REFERENCE	MEASURE NAME AND DESCRIPTION	
		standard, in the next period it is planned to conduct a series of information and educational activities to promote construction and renovation according to the nZEB standard. Measure reference in the Long-Term Reconstruction Strategy: ENU-2
MEN-2	Energy renovation programme for apartment buildings	The program encourages in-depth renovation of buildings and comprehensive renovation. In the case of buildings undergoing significant renovation, highly efficient alternative systems will be encouraged, to the extent technically, functionally and economically feasible, and special attention will be paid to ensuring healthy indoor climatic conditions, fire protection and risks associated with increased seismic activity. Reconstruction to the nZEB standard established for reconstruction needs to be more strongly encouraged. The implementation of the Program must be accompanied by strong promotional activities, technical assistance provided to applicants and it is necessary to ensure monitoring of energy consumption before and after energy renovation, for which it is necessary to create preconditions within Energy Management Information System. Savings are calculated assuming energy renovation of buildings to the level of meeting the requirements of the Technical Regulation by the regulation on rational use of energy and thermal protection in buildings, according to building construction periods, at an annual renovation rate of 1% at the beginning of the period (2021) is gradually increasing to 3% by 2030. Annual savings amount to 0.148 PJ. Measure reference in the Long-Term Reconstruction Strategy: ENU-3
MEN-3	Energy renovation programme for single family houses	The program will ensure the continuous implementation of the renovation of family houses by publishing public calls for grants each year in the period 2021-2030. The program should leave the possibility of implementing individual measures, but respecting the order of implementation of measures (e.g., replacing the heating system with a more efficient system using RES should be allowed only to those houses that have good thermal characteristics and do not need enclosure interventions). It is necessary to strongly encourage in-depth reconstruction and reconstruction to the nZEB standard established for reconstruction. In the case of buildings undergoing significant renovation, highly efficient alternative systems will be encouraged, to the extent technically, functionally and economically feasible, and special attention will be paid to ensuring healthy indoor climatic conditions, fire protection and risks associated with increased seismic activity. The program will also cover the segment of citizens at risk of energy poverty. Measure reference in the Long-Term Reconstruction Strategy: ENU-4
MEN-4	Energy renovation programme for public buildings	Renovation of public sector buildings needs to be directed towards the nZEB standard established for renovation wherever technically feasible. In the case of buildings undergoing significant renovation, highly efficient alternative systems will be encouraged, to the extent technically, functionally and economically feasible, and special attention will be paid to ensuring healthy indoor climatic conditions, fire protection and risks associated

REFERENCE	MEASURE NAME AND DESCRIPTION	
		with increased seismic activity. Funds need to be planned 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, penitentiaries, nursing homes, etc.) and that belong to category of central government buildings, for which there is a binding renovation target defined in Directive 2012/27 / EU on energy efficiency. Measure reference in the Long-Term Reconstruction Strategy: ENU-5
MEN-5	Energy renovation programme for buildings that have the status of cultural property	Protected buildings in terms of this Programme are those that can be classified into two categories: individually protected cultural property (individual building and construction complexes) and buildings located within the protected cultural and historical ensemble. The program does not include buildings protected as a preventively protected cultural property, nor buildings registered as cultural property. Two basic approaches to energy renovation of buildings that are the subject of this Programme have been developed: a complete (integrated) approach and an approach with the application of individual energy renovation measures. Measure reference in the Long-Term Reconstruction Strategy: ENU-6
MEN-6	Energy renovation programme for public lighting	Energy renovation of public lighting in the Republic of Croatia is currently being carried out using ESI funds from the European Regional Development Fund using a financial instrument of a loan with favourable interest rates offered to local and regional units self-government by Croatian Bank for Reconstruction and Development. HRK 152 million is available for this purpose, and the loan covers up to 100% of the eligible costs of the project. It is anticipated that this financial allocation will be used by 2020, and by 2023 at the latest. The estimated savings of this first phase of the Program are about 15 GWh in 2020 (2023). Given the significant potential that exists in public lighting systems, it is planned to use ESI funds in the next programming period 2021-2027. By programming a larger allocation of funds for this purpose, the existing potential could be used by the end of 2030, which is estimated at around 225-280 GWh. At the same time, the renovation of public lighting would meet the technical standards for road lighting, which means that traffic safety would be improved and light pollution would be reduced.
MEN-7	Energy management in the public sector	The public sector in Croatia is obliged to systematically manage energy, which is specifically regulated by the Energy Efficiency Act. The basis of this measure is Energy Management Information System. The strategic goal is to include and regularly monitor with Energy Management Information System all public sector buildings and public lighting systems by the end of 2030. Savings based on the activities of systematic energy management and the introduction of remote metering in the previous period were defined at about 335 TJ per year (according to the 4th National Energy Efficiency Action Plan). Measure reference in the Long-Term Reconstruction Strategy: ENU-7

REFERENCE	MEASURE NAME AND DESCRIPTION	
MEN-8	Energy management in the business (service and production) sector	Although large companies are obliged to conduct regular energy audits, this obligation does not ensure continuous care for energy consumption in the company nor does it cover small and medium-sized enterprises. In order to encourage companies to introduce certified energy management systems (such as ISO 50001), by 2020 a comprehensive analysis of the possibilities of using the tax system (including taxes and parafiscal levies) will be made to encourage companies to introduce such a system and thus ensure continuous care for energy consumption.
MEN-9	Informational accounts	One of the basic measures of informing consumers is the legal obligation of suppliers for submitting to consumers at least once a year information invoices, which contain information on energy billing and previous consumption of the end customer for billing meters that are the subject of the contract, which include comparison with average regular consumption or reference customer from the same category. It is desirable to reduce the frequency of application of this legal provision from the annual level to the monthly level, and it is absolutely necessary to ensure that the energy regulatory body monitors these obligations of energy suppliers. In addition, based on these regulations, it is necessary to further inform consumers about the content and meaning of bills, which is the task of the National Coordination Body for Energy Efficiency. One of the basic measures of informing consumers is the legal obligation of suppliers for submitting to consumers at least once a year information invoices, which contain information on energy billing and previous consumption of the end customer for billing meters that are the subject of the contract, which include comparison with average regular consumption or reference customer from the same category. It is recommended to reduce the frequency of application of this legal provision from the annual level to the monthly level, and it is absolutely necessary to ensure that the Croatian Energy Regulatory Agency monitors these obligations of energy suppliers. In addition, based on these regulations, it is necessary to further inform consumers about the content and meaning of bills, which is the task of the National Coordination Body for Energy Efficiency.
MEN-10	Energy efficiency information	Informing the general public and target groups will be carried out by organizing targeted info-campaigns related to specific programs to promote energy efficiency, especially energy renovation of buildings. National Coordination Body for Energy Efficiency will maintain a national energy efficiency portal and ensure continuous promotion of energy efficiency and energy services through the provision of up-to-date information. In the next period, special attention should be given to informing consumers about the duties of the supplier within the system of obligations.
MEN-11	Energy efficiency education	Training will be achieved through the continued implementation of the existing measure and the adaptation of activities to the needs and the real situation. It is especially important to work systematically on attracting young people to construction and other technical occupations, which will in the long run contribute to the availability of professional capacities for the implementation of energy renovation of buildings, which is the basis for achieving energy and climate goals. Through education in the field of energy efficiency, the principles of green building

REFERENCE	MEASURE NAME AND DESCRIPTION	
		will be set and applied: it is necessary to encourage the promotion and implementation of green building (construction according to the principles of sustainability) as an important segment of sustainable development and the circular economy.
MEN-12	Energy efficiency of the electricity transmission network	The current levels (2018) of losses in the transmission network of the Republic of Croatia amount to about 2% of the transmitted electricity, which is the amount at the level of other ENTSO-E transmission system operators. An important characteristic of the Croatian transmission network, both in terms of plant safety and support of market activities, and in terms of losses is the extremely strong connection with neighbouring power systems (interconnections). While on the one hand this significantly increases the security of the plant, on the other hand due to transit the network losses increase. In the period until 2030, Croatian Transmission System Operator will continue to implement measures related to the management of the power system and measures related to the development of the transmission network, for optimal (safe and efficient) management of the facility. For this measure, it is proposed, in addition to the provision of funds by Croatian Transmission System Operator, to program the use of ESI funds in the next programming period from 2021 to 2027.
MEN-13	Reduction of losses in the distribution network and introduction of smart grids	In the period until 2030, HEP-ODS will continue to carry out activities to reduce technical and non-technical losses in the electricity distribution network. A detailed analysis will determine the causes of increased losses in certain parts of the network and priorities for the implementation of activities to reduce technical and non-technical losses. Based on the experience from the implementation of the pilot project of introducing advanced networks in pilot areas with the use of ESI funds, it is necessary to program the continuation of the use of ESI funds in the next programming period from 2021 to 2027 for further development of advanced networks.
MEN-14	Increasing the efficiency of the district heating systems	In the existing large centralized heating systems, a large source of losses is the deteriorated steam and hot water network, and this measure foresees the continuation of the replacement of deteriorated steel hot water pipes and steam lines with new pre-insulated pipes and a technological shift to fourth-generation district heating. In smaller systems with their own boiler room, it is necessary to enable the reconstruction of boiler rooms, in particular by replacing them with high-efficiency cogeneration systems or systems using heat pumps. The measure also envisages the development of new heating and cooling systems, which use high-efficiency cogeneration or renewable energy sources. Given the provisions of Directive 2018/2002 on energy efficiency, and in particular with the introduction of the obligation of individual metering at the end consumer level, district heating systems have become systems with variable heat demand, which requires the introduction of advanced metering systems as an additional step to integrate different energy systems and to increase overall energy efficiency.

REFERENCE	MEASURE NAME AND DESCRIPTION	
MEN-15	Increasing the efficiency of the gas transport network	The potential for increasing energy efficiency of the gas transport system is largest in consumption of natural gas, which is mostly (70%) consumed for preheating natural gas before delivery to customers, and only a small part (30%) for heating business premises and various technological reliefs, i.e. system exhaust. In the upcoming period Plinacro will implement activities to improve energy efficiency in accordance with the Ten-Year Development Plan of the Gas Transport System of the Republic of Croatia 2018-2027.
MEN-16	Information, education and capacity building for RES use	Dissemination of information to the general public and target groups will be conducted through the organization of targeted informational campaigns related to investments in systems using renewable energy sources, especially in systems for own needs. Information, education and capacity building for the use of RES will be provided at the national level.
MEN-17	Spatial planning prerequisites for RES use	Defining guidelines and criteria for the regulation of specific spatial-functional elements for the use of RES, more advanced and cross-sectoral harmonization of spatial planning conditions for determining areas suitable for the construction of RES plants at the state, county and local level. Guidelines and criteria for determining the spatial planning conditions for the use of space intended for the construction of facilities for energy recovery of RES (specific spatial-functional elements in space) and for the exploitation fields of geothermal water for energy purposes will be adopted. Conditions for determining locations and construction of RES plants will be integrated into spatial plans at the state and county levels.
MEN-18	Promoting the RES use for production of electricity and heat	Providing financial incentives for development of projects for the use of RES for the production of electricity and heat. Encouraging the use of RES for electricity and heat production will be implemented at the national level.
MEN-19	Development of the regulatory framework for RES use	The existing legal framework needs to be amended and procedures and practices developed. The goal is to fully adopt the regulatory framework and established procedures at the national level by 2025.
MEN-20	Integrated planning of security of energy and energy products supply	The overarching measure to increase energy security is the integrated planning of security of supply in the context of all energy products and all energy systems. Integrated planning should be harmonized at the local, regional and national level, and in accordance with energy planning carried out by energy entities for energy infrastructure throughout the territory of the Republic of Croatia. In addition, integrated planning needs to be aligned with planning for alternative fuels and infrastructure for alternative fuels. This planning will be carried out as part of the revision of the Integrated Energy and Climate Plan, which needs to be drafted by 23 June 2023, and as part of the drafting and revision of future plans. To this end, it is necessary to analyze the existing regulatory framework and, if necessary, supplement it.

REFERENCE	MEASURE NAME AND DESCRIPTION	
MEN-21	Construction and use of energy storage	In order to increase the energy storage capacity of the system and increase the regulatory capacity of the electricity system, it is planned to build additional reversible power plants with a capacity of 150 MW before 2030. Furthermore, development of heat storage tanks for end customers, batteries, charging stations for electric vehicles that allow energy storage, and the use of other innovative energy storage technologies (financed from the EU funds) is planned.
MEN-22	Development and maintenance of centralised thermal systems	Centralised thermal systems have been identified as one of the priorities of the energy policy of the Republic of Croatia. The most significant potential for the development and improvement of existing centralised thermal systems is primarily to increase the energy efficiency of production units, infrastructure and equipment at end-users and to increase reliability and security of supply. Therefore, this measure envisages the maintenance and upgrading of existing DHS systems, stopping the trend of disconnecting customers from the DHS systems, introducing heat storage tanks powered by electricity, and using RES for DHS as well as replacing existing DHS production with renewable sources (e.g. biofuels) and use of heat pumps.
MEN-23	Refinery upgrade and transformation	Implementation of investments in upgrade and improvement of production in order to maintain the competitiveness of refineries.
MEN-24	Measures to increase energy efficiency by improving processes and process units	Increasing energy efficiency is achieved by implementing measures that contribute to reducing energy intensity through more rational use of energy and raw materials, by adding additives and by altering production processes and equipment at pumping stations and refineries, which contributes to reducing fugitive emissions.
MEN-25	Methane flaring	In order to reduce fugitive emissions, instead of fuming methane, methane is burned on a torch. In this way, methane emissions are reduced by 95-99% depending on the efficiency of the flares.
MEN-26	Development of the electricity transmission network	Croatian Transmission System Operator ltd. is, according to the Energy Act (Official Gazette, No. 120/12, 14/14, 95/15, 102/15, 68/18), an energy entity responsible for the management, operation and guidance, maintenance, development and construction of the transmission electricity network. According to the Electricity Market Act (Official Gazette, No. 22/13, 95/15, 102/15, 68/18, 52/19), the Croatian Transmission System Operator, as the owner of the 110 kV to 400 kV transmission network, is obliged to develop and adopt ten-year, three-year and one-year investment plans for the development of the transmission network. Ten-year development plans are updated annually. At the time of writing, the Ten-Year Transmission Network Development Plan 2019-2028 was relevant, with detailed elaboration for the initial three-year and one-year periods, which was approved by Croatian Energy Regulatory Agency in July 2019. The plan will be continuously updated throughout the implementation period of this document.

REFERENCE	MEASURE NAME AND DESCRIPTION	
MEN-27	Development of gas transmission system	Transmission system development planning is carried out through the preparation of the Ten-Year Gas Transmission System Development Plan, the development of which is the responsibility of the gas transmission system operator pursuant to the Gas Market Act (Official Gazette, No. 18/18, 23/20). The gas transmission system operator is the company Plinacro ltd. Ten-year plans for the development of the gas transmission system are updated on an annual basis, and are approved by Croatian Energy Regulatory Agency. At the time of adopting this document, the Ten-Year Plan for the Development of the Gas Transport System of the Republic of Croatia 2018-2027 was relevant. The plan will be continuously updated throughout the implementation period of this document.
MEN-28	Elaboration of the regulatory framework for active participation of customers on the electricity market	In order to enable the active role of network users in the electricity market, it is necessary to amend the existing regulatory framework in an appropriate manner, especially through the introduction of aggregators as market participants and through enabling the launch of a pilot project to provide ancillary services. Pilot projects will analyse in detail the services that users can provide to the distribution or transmission system operator. Possible types, scope, method and period of providing ancillary services will be analysed. Barriers to the use of ancillary services will be identified and ways to remove them will be suggested. Previously, an analysis of the potential for the provision of ancillary services and flexibility services with the response of consumption by network users will be conducted, based on which the method and model of providing ancillary services and the response of consumption by network users will be defined.
MEN-29	Introduction of advanced consumption metering systems and metering data management	In order to enable further development of energy markets and the active role of consumers in energy markets, advanced metering devices and systems at consumption level will be introduced.
MEN-30	Adoption and implementation of the Programme for Energy Poverty Reduction	Mitigation of energy poverty and the degree of vulnerability to it and establishment of an energy poverty monitoring system. Measure reference in the Long-Term Reconstruction Strategy: UET-5
MEN-31	Increasing energy efficiency and the use of RES in manufacturing industries	In the previous period, EUR 60 mil. was provided from the ESI funds, and based on Competitiveness and Cohesion OP. The absorption of funds was excellent, which proves that industrial plants in the Republic of Croatia have significant potential to improve energy efficiency, reduce energy consumption and reduce the share of conventional (fossil) fuels in total energy consumption by introducing renewable energy sources. The aim of this measure is to ensure the continued co-financing of the implementation of such measures in the manufacturing industries through grants and financial instruments.
MEN-32	Adoption and implementation of the Energy Poverty	Mitigation of energy poverty and the degree of vulnerability to it in the buildings owned and managed by the Central State Office for Reconstruction and Housing, in which residents are not able to participate in financing

REFERENCE	MEASURE NAME AND DESCRIPTION	
	Reduction Program, which includes the use of renewable energy sources in residential buildings in assisted areas and areas of special state concern for the period 2021-2025	the necessary repairs. Within the Program for Energy Poverty Reduction, which includes the use of renewable energy sources in residential buildings in assisted areas and areas of special state concern for the period 2021-2025, 413 residential buildings were identified for the needs of the Program, including 407 buildings from the working list and 12 additional, but 22 are included in other units, giving a total of 397 buildings. The priorities of the renovation were determined according to the observed shortcomings of the buildings, and the possible energy savings for heating and primary energy that will be achieved by the renovation of the buildings were assessed. A total of 397 buildings were covered, with a total area of 297,575 m2, for the renovation of which it is necessary to invest between HRK 297 and 355 mil. The total possible primary energy savings on all buildings is 27 GWh per year.
TRANSPORT		
MTR-1	Providing information to consumers on fuel economy and CO_2 emission of new passenger cars	Pursuant to the Ordinance on Availability of Information on Fuel Economy and CO_2 Emissions from Passenger Cars (Official Gazette, No. 7/15) each supplier of new passenger cars intended for sale shall provide consumers with information on the fuel consumption rate and specific CO_2 emission of passenger cars. The Ministry of Interiors, as the central body of state administration responsible for the road traffic safety, on the basis of the Ordinance once a year, not later than 31 March of the current year, prepares a Guidelines on cost-effectiveness of fuel consumption and CO_2 emission from new passenger cars available for purchase on the market in the Republic of Croatia. The Guidelines contain required information for each model of new passenger cars available in the domestic market. Extension of information to other categories of motorized road vehicles will be implemented within the measure.
MTR-2	Special environmental fee for motor vehicles	The existing system of payment of a special environmental fee for motor vehicles is regulated by the Act on the Environmental Protection and Energy Efficiency Fund (Official Gazette, No. 107/03, 144/12), and the Regulation on unit charges, corrective coefficients and detailed criteria and standards to determine the special environmental fee for motor vehicles (Official Gazette, No. 114/14, 147/14, 2/21). The special fee is charged taking into consideration the type of engine and fuel, engine operating volume, type of vehicle, CO_2 emissions and vehicle's age.
MTR-3	Special tax on motor vehicles	Based on the 'polluter pays' principle, the model's calculation is based on CO_2 emissions into the air from motor vehicles. The special tax is determined on the basis of the sales or market price of the motor vehicle, CO_2 emissions expressed in grams per kilometre, engine volume in cubic centimetres and the level of greenhouse gas emissions. This special tax encourages the purchase of energy efficient vehicles and vehicles with lower greenhouse gas emissions. The implementation of the measure is ensured through the enactment of the Act on Special Tax on Motor Vehicles (Official Gazette, No. 15/13, 108/13, 115/16, 127/17, 121/19).

REFERENCE	MEASURE NAME AND DESCRIPTION	
MTR-4	Monitoring, reporting and verification of greenhouse gas emissions in the fuels and energy lifetime	In accordance with the Act on Climate Change and Ozone Layer Protection (Official Gazette, No. 127/19) supplier that places the fuel on domestic market shall monitor greenhouse gas emissions per energy unit in the lifetime of the fuel. Suppliers have to draw up a report that has to be verified and submitted to the Ministry of Economy and Sustainable Development (Institute for Environment and Nature).
MTR-5	Legislative adjustments for cleaner transport	Through amendments to laws and bylaws, ensure the development of infrastructure for alternative fuels, raising the share of renewable sources in direct energy consumption in transport and promoting clean and energy efficient vehicles in road transport.
MTR-6	Financial incentives for the purchase of energy efficient vehicles	In the context of co-financing cleaner transport projects, it is necessary to define special co-financing lines for specific purposes, namely, for the purchase of electric vehicles, compressed and liquefied natural gas and hydrogen. Incentives for co-financing the purchase of vehicles will be primarily oriented towards alternative fuels for which the assessment of the existing situation has shown a minor representation in the total number of vehicles and will be time-limited until the minimum representation of vehicles is achieved. The minimum degree of market development shall be considered to be 1% of alternative fuel vehicles in the total number of vehicles registered in the country.
MTR-7	Development of infrastructure for alternative fuels	The objective of this measure is to facilitate the uptake of alternative fuels by users/consumers by strengthening the alternative fuels distribution infrastructure and implementing common technical specifications for this infrastructure. The measure follows Directive 2014/94/EU on the establishment of infrastructure for alternative fuels, the Act on the Establishment of Infrastructure for Alternative Fuels (Official Gazette, No. 120/16) and the National Policy Framework for the Establishment of Infrastructure and Development of Alternative Fuels in Transport (Official Gazette, No. 34/17) and encourages the construction of filling stations in accordance with the above documents. This measure will not directly affect the reduction of fuel consumption in traffic, but the development of infrastructure is certainly a necessary prerequisite for the development of the market of vehicles and vessels that use electricity, compressed and liquefied natural gas and hydrogen in Croatia. The incentive measures for infrastructure co-financing will be primarily oriented towards alternative fuels for which an assessment of the current situation has shown that the infrastructure is underdeveloped and will be limited in time until the situation monitoring shows minimal infrastructure coverage. The minimum infrastructure coverage will be considered to be the one that corresponds to the minimum infrastructure objectives from the National Policy Framework.
MTR-8	Promotion of integrated freight transport	The measure is regulated by the Act on Combined Transport of Goods (Official Gazette, No. 120/16) and the Ordinance on Incentives in Combined Transport of Goods (Official Gazette, No. 5/18), which stipulates

REFERENCE	MEASURE NAME AND DESCRIPTION	
		incentives for combined transport of goods by rail, inland waters or sea, and incentives for combined transport of goods on road sections.
MTR-9	Promotion of sustainable intermodal transport at national level	The measure follows the general and specific objectives defined in the Transport Development Strategy of the Republic of Croatia for the period from 2017 to 2030 in the context of energy efficiency of rail, road, maritime transport, inland waterway transport and urban, suburban and regional traffic (modernization of railways, signalling systems, renewal of locomotives, wagons, fleet of vessels, logistically integrated platforms, integrated public passenger transport, etc.). Development of rail and generally multimodal infrastructure fall behind in comparison to highway infrastructure in terms of quality and connectivity. Investments are planned to develop a sustainable, integrated trans-European climate-resilient transport network. In maritime and inland waterway transport, the possibilities of introducing appropriate mechanisms to ensure the transition to low-carbon solutions will be analysed, especially in terms of the application of alternative energy sources for navigation. In this context, an action plan for shipping will be defined, which will, among other things, define appropriate emission standards for the coming period. Also, in air transport, the Republic of Croatia will define a plan and develop detailed guidelines for achieving a significant reduction in greenhouse gas emissions.
MTR-10	Promotion of integrated and intelligent transport systems and development of alternative fuels infrastructure at local and regional level	It is necessary to promote sustainable development of urban transport systems through the optimization of logistics of transport of goods and intelligent management of public parking spaces (ICT technologies), introduction of integrated passenger transport, introduction of car-sharing schemes in cities, introduction of low-emission zones in cities, introduction of public city bicycles system and construction of the accompanying cycling infrastructure, intelligent traffic control (upgrade, adaptation and replacement of out of date signalling devices and equipment, installation of advanced traffic equipment and intelligent traffic lights equipped with the autonomous power supply system from renewable sources, constructing and equipping central operating centres for monitoring and management of intersections with installed traffic lights). At the local level, it is necessary to continuously prepare and implement Sustainable Mobility Plans in cities, as well as strategic plans that build on the existing planning practices, and take into account integration, participation and evaluation principles to meet the citizens' mobility needs now and in the future, and ensure better quality of life in cities and their surroundings. The activities will be accompanied by appropriate information and educational campaigns.
MTR-11	Training for drivers of road vehicles for eco-driving	The aim of the measure is to raise awareness of the benefits of energy efficient driving. Education on the eco-driving elements is carried out in short trainings (lasting 60-120 minutes per candidate) among the drivers who received their driver's license prior to the entry into force of the Ordinance on Training of Driver's License Candidates (Official Gazette, No. 13/09, 132/17), which introduced an obligation for all driving schools and instructors to carry out training on the elements of eco-driving during the standard training of candidates. Special elements of the national campaign should be devoted to eco-driving education for drivers of passenger cars, buses, commercial and heavy-duty vehicles.

REFERENCE	MEASURE NAME AND DESCRIPTION	
MTR-12	Promotion of boat transport using alternative fuels	In accordance with the "National Coastal Shipping Service Development Plan" and considering that the Republic of Croatia is a maritime land with developed longitudinal liner traffic, and in addition has navigable river routes and lakes, this measure would co-finance the projects of gradual transition of the existing obsolete fleet to alternative and/or hybrid solutions and new construction. Ships that use alternative fuels are generally more expensive than ships that use conventional fuels, so there is no expressed interest of shipowners to invest in such ships. Therefore, in the initial period it is necessary to financially support the conversion/construction of such ships to the extent that the purchase price is equalized or puts such a shipowner in the same position as a shipowner that uses ships with conventional fuel. This measure builds on the measure related to the development of infrastructure for alternative fuels in terms of permanent users/consumers on that infrastructure, and at the same time significantly affects the potential reduction of pollution of the sea, rivers and lakes.
MTR-13	Advanced biofuel market development plan	Increasing the share of RES in transport by 2030 through the development of the advanced fuels market and achieving the planned share of advanced fuels in direct energy consumption in transport through the criteria of the lowest cost and the largest multiplier. The implementation of the measure is based on amendments to relevant laws and bylaws based on the Directive on the Promotion of the Use of Energy from Renewable Sources, and in particular the establishment of conditions for monitoring the sustainability of biofuels and greenhouse gas savings.
MTR-14	Decarbonisation of transport through the production of advanced biofuels from agricultural production residues and energy crops with integrated carbon capture, use and storage	Creating a long-term sustainable biomass supply chain and bioethanol production with negative net greenhouse gas emissions An industrial complex for the production of advanced bioethanol will be built based on the Axens' (France) patented innovative FUTUROL ™ technology with the integration of BIO-CCUS. The plant will have a capacity of 55,000 tons per year of advanced bioethanol to be distributed on the market through commercial channels of INA and MOL Group. About 52,000 t/y of biogenic carbon dioxide will be captured and stored in domestic oil fields using BIO-CCUS technology. The production of advanced bioethanol will use a combination of agricultural residues, mainly cereal and maize straw, and the energy plant Miscanthus x giganteus, in accordance with Part A of Annex IX to Directive 2018/2001 on the promotion of the use of energy from renewable sources, which lists the raw materials acceptable for production of advanced biofuels. The industrial complex will consist of a plant for the production of advanced bioethanol, for the production of biogas and a high-efficiency cogeneration plant.
INDUSTRIAL PROCESSES AND USE OF PRODUCTS		
MIP-1	Reducing the share of clinker in cement production	Increasing the share of mineral additives in cement depending on the composition of the raw material, the availability of additives of appropriate composition on the market and the market requirements for certain types of cement.

REFERENCE	MEASURE NAME AND DESCRIPTION	
MIP-2	Limiting fluorinated greenhouse gas emissions	Implementation of Regulation (EU) 517/2014 in the Republic of Croatia is regulated by the Law on the Implementation of Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 (Official Gazette, No. 61/17, 118/18), which is in force since 1 January 2019. The measure defines activities and procedures for the prevention of fluorinated greenhouse gas emissions, conducting equipment leakage checks, use of equipment with leak detection systems, keeping records of equipment on which leakage checks need to be performed, collection of fluorinated greenhouse gases to ensure their recycling, reclamation or destruction, the development of a producer responsibility system for the collection of fluorinated greenhouse gases and their recycling, reclamation or destruction, and the implementation of training and certification programs.
MIP-3	Gradual reduction of the amount of fluorocarbons that can be placed on the market	The measure concerns the gradual limitation of the amount of fluorocarbons available on the EU market by 2030 to 21% of the total amount of fluorocarbons placed on the market during the reference period 2009 to 2012, as established by Regulation (EU) 517/2014. Regulation (EU) 517/2014 introduces a quota system for placing fluorocarbons on the market. The calculation of the benchmarks and the allocation of quotas should be based on the reported quantities of fluorocarbons placed on the market during the reference period from 2009 to 2012. Quota for placing fluorocarbons on the market shall be allocated to each manufacturer and importer for each year, starting in 2015, on the basis of benchmarks, applying defined percentages to calculate the maximum amount of fluorocarbons to be placed on the market and the allocation mechanism.
MIP-4	Restrictions and prohibitions on placing certain products and equipment on the market	The measure concerns restrictions and prohibitions on the placing on the market of certain products and equipment containing fluorinated greenhouse gases, as laid down in Regulation (EU) 517/2014. Fluorinated greenhouse gases with high greenhouse potential are limited for use in new refrigeration and air conditioning equipment, fire extinguishing systems, foam blowing agents and aerosols.
MIP-5	Reduction of fluorinated greenhouse gas emissions from mobile air conditioning systems	Directive 2006/40/EC of the European Parliament and of the Council of 17 May 2006 relating to emissions from air-conditioning systems in motor vehicles and amending Council Directive 70/156/EEC has been implemented in three phases. The last phase came into force on 1 January 2017 by limiting the possibility of retrofitting air conditioning equipment designed to contain fluorinated greenhouse gases with a global warming potential above 150 in motor vehicles and banning the charging of air conditioning equipment with these gases.
AGRICULTURE		

REFERENCE	MEASURE NAME AND DESCRIPTION	
MAG-1	Change in livestock diet of and feed quality	Measures taken are aimed at regulating digestive processes (diet, feed selection, use of additives to regulate micropopulation activity). In practice, several measures are usually applied at the same time.
MAG-2	Improvement of livestock facilities and manure management systems	By improving and changing existing manure management systems and using the best available techniques, it is possible to reduce emissions.
MAG-3	Modification of the livestock system	Measures that achieve effects on reducing greenhouse gas emissions refer to measures that increase the intensity of production per animal and per unit time.
MAG-4	Anaerobic decomposition of manure and biogas production	The introduction of biogas plants reduces methane emissions due to the use of litter as a renewable source for electricity production
MAG-5	Improving the breeding and selection program, animal health and welfare	The aim of the measure is to determine both phenotypic and genetic variations in predicted CH_4 emissions, to determine the potential of genetics to reduce CH_4 emissions in dairy cows, and to increase production intensity.
MAG-6	Improvement and change of tillage system (reduced tillage)	Reduced tillage is the result of scientific research and practical audits that result in changing the conventional tillage system by reducing tillage depth, omitting one or more operations, reducing the frequency or complete omission of tillage, reducing the cultivated area and retaining crop residues. The direct impact on greenhouse gas emissions is primarily related to the significant impact on the organic carbon content in the soil and the smaller number of operating hours of machines.
MAG-7	Expansion of crop rotation with higher share of legumes	Sowing leguminous crops binds atmospheric nitrogen, reduces the risk of groundwater pollution, the soil is enriched with organic matter, which has multiple positive effects on improving and maintaining favourable physical, chemical and biological properties of the soil.
MAG-8	Intensification of crop rotation using intermediate crops	By sowing intermediate crops that can be used for livestock feeding or plowing for green manure, the remaining nutrients will be used, prevent further evaporation of water from the soil, reduce carbon loss from the soil, prevent nitrogen leaching into groundwater and increase organic matter in the soil.
MAG-9	Improving methods of applying mineral fertilizers	Reducing the consumption of mineral fertilizers is an indirect benefit from other measures that reduce the need for their application, but with proper fertilization practice. In addition, the application of slow-release fertilizers can directly affect the total amount of mineral fertilizers applied.

REFERENCE	MEASURE NAME AND DESCRIPTION	
MAG-10	Improving methods of applying organic fertilizers	Organic fertilizers originate from organic sources such as solid manure or slurry and plant or animal residues, and strongly stimulate the activity of soil microbes compared to mineral fertilizers. Using injectors for direct injection into the soil reduces nitrogen loss due to volatilization
MAG-11	Agroforestry	Agroforestry is a common name for land management systems in which permanent woody species are integrated with the cultivation of crops and/or animals on the same surface unit. Some agroforestry systems (e.g. Agro-silvopastoral system) are significant carbon removals. It is necessary to establish experimentally the applicability of agroforestry in our conditions with regard to different forms and divisions, but also to different needs.
MAG-12	Hydromeliorative interventions and disaster protection systems	In addition to the controlled application of mineral fertilizers, controlled drainage, reuse of drained water and the use of water of appropriate quality are important for reducing nitrate emissions. Drainage has the function of draining excess water. Also, the change in soil-air ratios affects the activity of beneficial microorganisms
MAG-13	Introduction of new cultivars, varieties and cultures	Reduction of mineral nitrogen application through the application of new varieties with drought and disease resistance, as well as specific legumes that have the ability of symbiotic relationship with nodule bacteria.
MAG-14	Change in people's diet	Growing cereals for animal feed produces much more greenhouse gases than producing cereals for human consumption. By increasing the consumption of foods of plant origin in the diet, significant reductions in emissions can be achieved, as well as water savings.
MAG-15	Collection and processing of agricultural plantations and residues for energy purposes	Energy utilization of post-harvest residues (with emphasis on field crops) is one of the most important ways of producing energy from biomass in the Republic of Croatia. Other possible sources are the remnants of the winter harvest of almost all horticultural species, as well as fast-growing crops for energy production that are planted/sown exclusively for the production of biomass with the aim of its conversion into energy. The establishment of collection and logistics centres for biomass with the use of existing infrastructure (utilities, competence centres, business zones) will reduce the unit cost of production of biomass products and capitalize on innovation capacity and necessary equipment for innovative biomass products for the bioeconomy. Collection and logistics centres will act as a link between the farmer who owns biomass, processing biomass into new products with higher added value, developing new products and placing these new products on the market.
WASTE		

REFERENCE	MEASURE NAME AND DESCRIPTION	
MWM-1	Preventing the generation and reducing the amount of solid waste	It is the first in the order of priority in the waste management, pursuant to the Sustainable Waste Management Act (Official Gazette, No. 94/13, 73/17 and 14/19). Waste generation prevention and reduction includes municipal solid waste, industrial waste and sludge from wastewater treatment plants. Waste prevention is achieved through the process of reuse and the use of by-products and the repealing of waste status, which will directly affect the reduction of the total amount of waste. The implementation of waste prevention measures is defined by the Waste Prevention Plan and the Plan for the Prevention and Reduction of Food Waste in the Republic of Croatia 2019 – 2022, which is prepared and proposed to the Republic of Croatia Government by the Ministry of Agriculture. The most important measures in terms of waste prevention are the establishment of Centres for reuse and provision of the necessary equipment for home composting as well educational activities. This measure is achieved by cleaner production, education, economic instruments and enforcement of regulations in waste management, and by investing in modern technologies that enable material recovery and chemical recycling of waste (production of various industrial compounds such as ethylene, ammonia, etc., as well as various fuels such as hydrogen, synthetic gas and carbon-based liquid fuels). According to the Act, quantitative targets and deadlines for reducing the total amount of waste disposed to non-compliant landfills were defined. Disposal of waste to non-compliant landfills in Croatia was prohibited after 31 December 2017. According to Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018 amending Directive 1999/31/EC on the waste landfills, Member States should take the necessary measures to ensure that by 2035 the amount of landfilled municipal waste will be reduced to 10% or less of the total amount of municipal waste generated (by weight). The Republic of Croatia was given the possibility of a delay of five years to meet the target because it is among the Member States that are in 2013 landfilled more than 60% of its municipal waste. Accordingly, this goal will have to be met by 2040. In this case, Croatia must take the necessary measures by 2025 to reduce the amount of landfilled municipal waste to 25% or less of the total amount of municipal waste generated (by weight).
MWM-2	Increasing the amount of separately collected and recycled solid waste	Beside the Sustainable Waste Management Act, the Waste Management Plan of the Republic of Croatia for the period 2017 – 2022 (Official Gazette, No. 3/17) also defines the quantitative targets and deadlines for increasing the amount of separately collected and recycled waste. Waste management objectives are prescribed to encourage the transition to a European circular economy with a high level of resource efficiency, in which the value of products, materials and resources is maintained for as long as possible, and waste generation is reduced to a minimum.

REFERENCE	MEASURE NAME AND DESCRIPTION	
		In order to contribute to the European circular economy, according to Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste, Croatia should take the necessary measures designed to achieve the following targets: • at least 50% by weight of municipal waste and waste from other sources whose waste streams are similar to that of municipal waste, including at least paper, metal, plastic and glass, should be recovered by recycling and preparation for re-use; • at least 70% by weight of non-hazardous construction waste, other than natural materials determined by the waste code 17 05 04 - soil and stones other than those mentioned in 17 05 03, should be recovered by recycling, preparation for re-use and other material recovery procedures, including backfilling, where waste is used as a substitute for other materials; • by 2025, the preparing for re-use and the recycling of municipal waste should be increased to a minimum of 55% by weight; • by 2030, the preparing for re-use and the recycling of municipal waste should be increased to a minimum of 60% by weight; • by 2035, the preparing for re-use and the recycling of municipal waste should be increased to a minimum of 65% by weight. Croatia was given the possibility of a delay of five years to meet the targets because it is among the Member States that are in 2013 prepared for re-use and recycled less than 20% of its municipal waste. The five-year delay is included in the projections. Accordingly, Croatia must take the necessary measures designed to achieve the following targets: • by 2025, the preparing for re-use and the recycling of municipal waste should be increased to a minimum of 50% by weight; • by 2030, the preparing for re-use and the recycling of municipal waste should be increased to a minimum of 55% by weight; • by 2035, the preparing for re-use and the recycling of municipal waste should be increased to a minimum of 60% by weight.
MWM-3	Ensuring the system of treatment and use of landfill gas	The Ordinance on the Methods and Conditions for the Waste Disposal, Categories and Operational Requirements for Waste Landfills (Official Gazette, No. 114/15, 103/18, 56/19) and Ordinance on Waste Management (Official Gazette, No. 117/17) regulate technical requirements for landfill operation, which reduce possible adverse effects of landfills on the environment. At landfills where landfill gas occurs it is necessary to secure a gas collection system, and that gas must be treated and used. If collected landfill gases cannot be used for energy production,

REFERENCE	MEASURE NAME AND DESCRIPTION	
		they should be flared in the area of the landfill and the emission of methane into the atmosphere should be prevented. Implementation of binding targets for reducing of waste disposal and waste recycling, described within measures Preventing the generation and reducing the amount of solid waste and Increasing the amount of separately collected and recycled solid waste, affects the amount of generated landfill gas.
MWM-4	Reducing the amount of disposed biodegradable waste	The aim of this measure is to reduce the amount of biodegradable fraction of waste disposed at landfills, thus reducing methane emissions resulting from anaerobic decomposition of waste. Pursuant to the Sustainable Waste Management Act, quantitative targets related to the reduction of biodegradable municipal waste disposed to landfills were established. To prevent the disposal of biowaste at landfills and contribute to the achievement of other goals of waste management, it is necessary to encourage citizens to compost. The goal is to achieve that households separate biowaste from other municipal waste by disposing of it in biowaste containers. This measure will cover rural areas, i.e. suburbs of urban areas with a larger number of independent housing units with infield. In the territory of the Republic of Croatia, by implementing this measure, it is possible to reduce up to 90,000 tons of biowaste per year. Since a significant part of biowaste is food waste, it is necessary to continue interdepartmental activities to prevent and reduce the generation of food waste. Since food waste represents a waste of natural and human resources and contributes to greenhouse gas emissions, in order to contribute to the achievement of objective 12.3. UN Agenda 2030 for sustainable development, i.e. reduction of food waste at the level of retail and consumers by half and reduction of food losses in general along the entire food chain, it is necessary to implement activities and measures envisaged by the Plan for Prevention and Reduction of Food Waste 2019-2022. Implementation of binding targets for reducing of waste disposal and waste recycling, described within measures Preventing the generation and reducing the amount of solid waste and Increasing the amount of separately collected and recycled solid waste, affects reducing the amount of disposed biodegradable waste.
MWM-5	Use of biogas for biomethane production and electricity and heat generation	The measure is associated with measures for promoting the use of renewable energy sources for electricity and heat generation and obligation to use renewable energy sources in transport and refers to the mandatory use of biowaste as a substrate in biogas plants that produce biogas to be used for the biomethane production and electricity and heat generation. The potential for reducing CH_4 emission (produced by anaerobic decomposition of biodegradable fraction of waste) is included in the measure Reducing the amount of disposed biodegradable waste. The potential for reducing CO_2 emission, which can be achieved by applying this measure, is calculated in the Energy sector.

REFERENCE	MEASURE NAME AND DESCRIPTION	
LAND USE, LAND USE CHANGE AND FORESTRY (LULUCF) **AND RELATED ACTIVITIES**		
MLF-1	Improvement of the Land Management Strategy of the Republic of Croatia	By 2027, it is necessary to improve the land management system of the Republic of Croatia. In this regard, the following activities are needed: 1. Establishment of a unique land information system in the Republic of Croatia or determine the areas of individual LULUCF land categories using spatially accurate data, for each land category and for each type of land change from one land category to another 2. Conduct analyses of all LULUCF land categories depending on cover, land use and management practices used on each land and associated emissions/sinks to consider the potential of each repository within each LULUCF land category to reduce emissions and increase greenhouse gas sinks 3. Preparation of a detailed projection of the development of future emissions/sinks in the LULUCF sector after the implementation of the above analysis The calculation of emissions/removals in the LULUCF sector and projects should form the basis for planning the use and management of LULUCF land categories for each of the repositories. The development of a Land Management Strategy is implied in order to properly define measures that will be implemented on a particular land category and which will reduce emissions and increase the removal of greenhouse gases in the Republic of Croatia. Improvement and definition of fire protection measures should form an integral part of this strategy. Choose technologies and methods (RES, golf courses, etc.) that enable the return of land to the basic agricultural or forestry purpose after use, and wherever possible to use the institute of "incomplete expropriation, i.e. the right of easement".
MLF-2	Carbon accumulation on the surfaces of existing forests	Implementation of activities that contribute to increasing the carbon stock content in forests, especially in biomass storage, and the implementation which ensures removals in a certain period higher than those defined by the Forest Reference Level (FRL). These activities are, for example, reforestation, transfer of stands to a higher form of cultivation, selection of species for filling, etc. Maintaining removals higher than those defined by the FRL also ensures an increase in emission allowances that can be transferred to sectors outside the ETS. Maintaining removals larger than that defined by the FRL also ensures the use of flexible mechanisms. In the future, it is necessary to assess the effectiveness of implemented measures and activities from the Rural Development Program of the Republic of Croatia for the period 2014-2020 to reduce/maintain emissions and increase/maintain greenhouse gas sinks and develop new guidelines for further management in the forestry and agricultural sector along with implementation of measures to mitigate and adapt to climate change. It is necessary to promote the

REFERENCE	MEASURE NAME AND DESCRIPTION	
		management of land categories that are useful for climate and environment, and to develop guidelines for further development based on the knowledge and experience gained from the implementation of this measure.
MLF-3	Implementation of afforestation works and remediation works of burned areas	Afforestation on non-forest areas (in terms of IPCC methodology) is an activity that generates sinks. Due to regulations in the field of nature protection which ensure the preservation of natural habitat types of interest to the European Union throughout its territory, the Republic of Croatia is not able to dispose of all grassland areas (according to national regulations: non-overgrown productive forest land) for afforestation. Given that in the Republic of Croatia there are agricultural areas on which no production takes place and which have been neglected for many years, when improving the land management system, the problem of these areas must be adequately addressed. It is necessary to assess the justification of the conversion of these areas into forest areas by the implementation of afforestation. It should be taken into account here that when calculating sinks on repurposed areas due to afforestation, there is no limit to the application of the amount of sinks, and that these sinks are fully taken into account in the calculation. It is also necessary to assess the effects of afforestation of additional non-overgrown, productive forest land on the fulfilment of obligations of the Republic of Croatia related to the use of renewable energy sources. It is necessary to develop guidelines for further development based on the knowledge and experience gained through the implementation of afforestation activities. In case of introduction of afforestation measure on neglected agricultural land, the measure will require strengthening of seed production and nursery service in the forestry sector and cultivation of planting material necessary for the implementation of these works. With the expected rise in temperature and increased prospects for droughts due to climate change, the number of fires and burned areas will increase. It is necessary to develop detailed guidelines and provide funds (EU funds, OKFŠ Fee) for the implementation of remediation of burned areas and the implementation of clearing and thinning works in forests in the karst area as breeding measures with fire-fighting effect. Conduct scientific research in order to determine the best methods of afforestation taking into account the specifics of the terrain on which afforestation is carried out, with special emphasis on the selection of types of afforestation.
MLF-4	Production and use of wood and wood products	By harmonizing available data and statistical reports, and new research to harmonize the information available for the purposes of various reporting to international organizations in order to achieve more accurate, transparent and quality reporting, but also to create harmonized bases for medium and long-term strategies in the forestry and wood processing sector. Mapping of forestry and wood industrial production is implied. Encourage the use of wood products in traditional and new products in order to increase the sink and reduce greenhouse gas emissions in the storage of wood products. This is also required by the regulation of exports of unprocessed and semi-processed wood, which encourages the development of the domestic wood industry, and the regulation of energy wood exports increases the share of energy production from renewable sources, thus fulfilling international obligations. It is necessary to promote activities that generate sinks and that ensure that wood products and wood

REFERENCE	MEASURE NAME AND DESCRIPTION	
		for energy purposes are used in ways that contribute to meeting both EU targets by 2030 (reducing emissions and increasing the share of renewable sources in total energy consumption) and are useful for climate and environment. It is necessary to develop guidelines for further development based on the knowledge and experience gained from the implementation of this measure.
MLF-5	Cropland management	Carrying out activities in the management of areas for agricultural production in a way that contributes to reducing the emission factor is of interest to family farms. Management practices for these areas that may have an impact on emissions and removals, for example in soil storage are: tillage methods, lifetime of plantation/crop (rotation period) and plantation/crop type, fertilizer application, residue management, erosion control, irrigation system application etc. It is necessary to promote activities in a way that is beneficial for the climate and the environment, and to develop guidelines for further development based on the knowledge and experience gained from the implementation of this measure.
MLF-6	Grassland management	Implementing pasture management activities in a way that contributes to reducing the emission factor is of interest to family farms. It is necessary to promote activities in a way that is beneficial for the climate and the environment, and to develop guidelines for further development based on the knowledge and experience gained from the implementation of this measure.
MLF-7	Implementation of technical projects and scientific research in the LULUCF sector	In the period until 2030 and 2050, it is necessary to provide financial resources for the implementation of technical and scientific projects in the LULUCF sector. Scientific projects should be able to develop different models for the transition to a higher level of IPCC methodology (Tier 3) with the aim of more accurately identifying greenhouse gas emissions/sinks and consequently planning measures to reduce emissions and increase sinks.